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THE

FIRST PRINCIPLES

OF

CHEMISTRY.

THE

FIRST PRINCIPLES

OF

CHEMISTRY.

BY

WILLIAM NICHOLSON.

THE SECOND EDITION, WITH IMPROVEMENTS.

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TO

HENRY CAVENDISH, ESQ.

F. R. S. AND A. S.

AS AN ACKNOWLEDGMENT

OF

THE NUMEROUS ADVANTAGES

WHICH

THE SCIENCE OF CHEMISTRY

HAS RECEIVED

FROM HIS DISCOVERIES:

THIS TREATISE

IS

RESPECTFULLY INSCRIBED.

PREFACE.

I HAVE ſpared no pains in collecting materials for the Treatiſe I now preſent to the world: I have condenſed thoſe materials into one volume, with more labour than I might have employed in diſtributing them into two or three: and I have printed it on a page unuſually full, at the ſame time that I have revived an ancient and uſeful practice of annexing ſide notes and references; which I believe has fallen into neglect, becauſe it requires great care in the author, uncommon attention in the printer, and adds to the expences incurred by the publiſher.

If the work ſhould not therefore prove to be ſo uſeful as my intention deſigned it, the defects will have ariſen chiefly from a want of that ability, which he who has it not, can by no exertion attain. The attempt itſelf is a proof, however, that I indulge expectations of a very different kind.

I believe I ſcarcely need remind the man of ſcience, that the great number of labourers in the chemical examination of bodies, has rendered it a difficult taſk to collect the various facts, which lie diſtributed in the acts of academies, and a variety of literary journals. It is not very eaſy to procure theſe books: and the peruſal of them produces a voluminous table of references; in which ſome things may be overlooked, even when noted. A certain degree of imperfection muſt ariſe, in every general treatiſe, from this cauſe. I have endeavoured to diminiſh it as much as poſſible.

In treating of facts long ſince eſtabliſhed, and ſuch whoſe diſcoverers are unknown to me, I have not quoted my authors; for, though I would gladly do juſtice to all claims, yet the inveſtigation of chemical hiſtory is foreign to the object of my preſent purſuit. Whenever I have quoted, it is to be underſtood that the authors are worthy of credit and reſpect; and that the reader will, in almoſt every inſtance, find his advantage in conſulting them for a fuller account of the ſubject. But I have quoted theſe only when it appeared neceſſary either to complete the information intended to be conveyed, or to clear myſelf from ſeeming to lay claim to their diſcoveries.

With regard to nomenclature and theory, I have attempted to keep clear of every ſyſtem. I have called things by ſuch names as are moſt in uſe, except where the uſual name pointed too evidently

dently at theories either long ſince exploded, or not yet proved: and in the relation of facts I have found it much leſs difficult to exclude theoretical alluſions than I at firſt apprehended, when I formed the determination of confining the theory, for the moſt part, to the ends of chapters. It would be very advantageous to ſcience if this reſolution, which I have adhered to with my beſt endeavours, were more generally adopted. I do not, however, wiſh to be thought blind to the advantages of an uniform nomenclature, or a conſiſtent theory; but muſt urge my conviction that the former ought to be founded on the moſt incontrovertible facts only, becauſe the nomenclature of any mere theory may be productive of worſe conſequences than the moſt confuſed ſet of terms can poſſibly occaſion. The ſyſtemizing of words, inſtead of things, is the fruitful ſource of paralogiſm; and it is by falſe reaſoning of this kind that a well-methodized hypotheſis may be ſupported, long after the pretended facts are overthrown upon which it was originally built. Upon the two theories of chemiſtry I have ſpoken like one who admits neither in any other way than as probable ſuppoſitions, which have not yet been experimentally eſtabliſhed. The logic of the managers of the controverſy for and againſt phlogiſton, appears to me to be exceedingly defective in a great number of inſtances. The exiſtence of this chemical element is indeed very far from being well aſcertained; but, on the other hand, there are many difficulties which attend the conſideration of chemical facts without it. As I think the antiphlogiſtic hypotheſis equally probable with the modified ſyſtem of Stahl, and more eſpecially as the excellent works of a number of French chemiſts are written in the language of that hypotheſis, I have judged it proper to explain both. And this I have endeavoured to do in ſuch a way, as to create in the chemical ſtudent an habit of ſteadily and calmly attending to the operations of nature; inſtead of indulging that haſty diſpoſition for theorizing, which indeed might paſs, on account of its evident impropriety, without any earneſt cenſure, if we had not the mortification to ſee it too much practiſed by men entitled to the beſt thanks of the ſcientific world, and on that account poſſeſſing greater power to miſlead.

London,
Jan. 25, 1790.

I HAVE carefully reviſed the ſecond Edition of this Work: the new diſcoveries are inſerted; and no exertions have been ſpared to render it worthy of the diſtinguiſhed approbation it has met with.

London,
Nov. 10, 1791.

CONTENTS.

BOOK I.

GENERAL CHEMISTRY.

Chap. I. General Obſervations on Chemiſtry, and the Means by which its Operations are performed. — — — Page 1

CHEMISTRY defined. Analyſis. Syntheſis. Heat. Analyſis by heat. Attraction. Chemical attractions—act by means of heat. Art of the chemiſt. Elective attractions. Dry and humid way. Terms of art.

Chap. II. Of Heat. — 5

Of the word Heat. Temperature. Cauſe of temperature. Common temperature. Conductors of heat. Solid, fluid, and vaporous ſtates. Expanſion. Changes by heat do not follow the denſity, &c. of bodies. Irregularities. Elaſtic fluids. Quantity of heat in equal bodies: — differing in temperature — in unequal bodies. Quantities required to change temperature. Thermometer:—its requiſites. Mercurial thermometer. Correſpondence of the expanſions of mercury with the increments of heat aſcertained by De Luc: — by Crawford. Quantities of heat in bodies of different kinds: — relative: — abſolute. Example. Comparative heat. Capacity. Capacities in various ſtates — changes by chemical actions. Inferences. Ice and water. Stationary temperature, or freezing point. Natural zero of temperature. Capacity of ſteam. Boiling-water point of temperature. Evaporation produces cold. Freezing by evaporation. Freezing mixtures. Fixed temperature of freezing mixtures.

mixtures. Freezing proceſſes by diſſolving ſalts in water. Mixture of ſalts for freezing water. General view of the agency of heat. Advantages ariſing from the changes of capacities. Whether heat be matter or motion. The philoſophy of heat admits no analogy. Diminution of capacity increaſes weight.

Chap. III. The Conſtruction of the Thermometer. — — 23

Conſtruction. To determine the cylindrical form of the tube. Method of blowing thermometers. Filling with mercury. Boiling the mercury in the tube. Caution. Trial of the proportion between the bulb and the tube. Hermetical ſealing of the tube. Proof of internal vacuum. Adjuſtment of the fixed points. Freezing. Boiling. Adjuſtment for errors of the tube. Standard thermometer. Caſes in which the mercury need not be boiled. Scales of thermometers. Fahrenheit's. Reaumur's. Celſius's. Reduction of degrees of thermometers of various ſcales.

Chap. IV. On Combuſtion, and the Application of Heat to chemical Purpoſes. — 32

Heat produced by friction; hammering; flint and ſteel; the ſolar focus; chemical mixtures; and by combuſtion. Proceſſes by heat. Roaſting; calcination; fuſion; digeſtion: cementation; evaporation; concentration; diſtillation; rectification; ſublimation. Flowers. Sublimates. Inſtruments. Crucibles; cucurbits, or matraſſes; retorts; receivers; alembic — of glaſs; — of metal. Stills for ardent ſpirit. Furnaces. Melting furnace; reverberatory furnace. Fuel. Chemical bath. Coating. Lutes. Fat lute. Lamp. Facility of making experiments. Moveable furnaces — for open fire — wind furnace — reverberatory furnace — blaſt furnace. The blow-pipe. Artifice of blowing through it. Flame urged by the blow-pipe. The ſubject to be heated. Advantages of this inſtrument: — its uſe rendered eaſy by bellows. Blow-pipe with vital air.

Chap. V. Concerning the Methods of making Experiments on Bodies in the Fluid and in the Aeriform State. — — 47

Apparatus for denſe fluids — for elaſtic fluids. Body and tube. Stand or ſupport of wire. Gun-barrel. Phials with quickſilver. Burning lens, or mirror. Apparatus with mercury.

Combuſtion

Combuſtion of air. Meaſuring tubes. Eudiometers. Management of powders. Electric ſpark. Holes drilled in glaſs. Impregnation of water with fixed air. Dr. Nooth's apparatus: — its valve defective. Improvements in diſtillation. Combination of receivers. Improved receiver. Remedy againſt abſorption.

Chap. VI. Concerning the Balance and Weights, with a Comparative Table of the various Weights made uſe of in Europe. — — 59

Balance deſcribed. Points of ſuſpenſion. Fulcrum. Propoſitions. Weighing with a balance which is not equibrachial. Conſtruction of the balance. The turn. Accurate weighing is ſlow. Long beams. Sets of weights. Common pile. Biſection. Wire rings. Number of weights required to form a ſet. Decimal ſet of weights. Account of ſome balances. The balance of Muſchenbroek:—of Bolton: —of Mr. Read:—of Mr. Whitehurſt:—of the Author:—of Mr. Alchorne:—of Dr. Geo. Fordyce:—of Mr. Magellan:—of the Royal Society. Inferences. Compariſon of weights:—by Monſ. Tillet.

Chap. VII. On the Attractions exerted between Bodies; particularly thoſe which the Chemiſts call Elective Attractions. —— 71

Great importance of the knowledge of the actions between the parts of bodies. Inertia of matter. Extenſion. Gravity may perhaps be modified:—but is not found to vary in experiments. Uſual inference. Effects of attraction. Coheſive attraction differs from gravity. Elective attraction:—does not depend on denſity—probably on figure. Aggregation. Mixture. Combination, or compoſition. Integrant and component parts. Elements, or firſt principles. Simple combination. Suſpenſion. Solvent, or menſtruum. Water. Cauſe of error in eſtimating the attractions. Limits of ſaturation:—in fluids: — in general. Solution aſſiſted by heat. Medium of combination. Separation, or precipitation. Simple elective attraction. Examples:—in the humid way:—in the dry way. Conjectural inference. Double elective attraction. Example: in the humid way:—in the dry way. Numerical expreſſion of affinity. Mechanical properties of bodies do not follow the properties of their component parts. Utility of theſe changes. Cryſtallization. Polarity of the particles of bodies.

BOOK II.

PARTICULAR CHEMISTRY.

SECTION I.

OF THE GENERAL PRINCIPLES OF BODIES.

CHAP. I. Concerning the General Diviſion of Chemical Principles. — 83

Arrangement. Enumeration. Animal, vegetable, and mineral kingdoms.

CHAP. II. Concerning Heat, Light, and Phlogiſton, conſidered as Component Parts of Bodies. — — 87

Heat. Light. Subtle fluid. Light and heat differ. Phlogiſton. Queſtion concerning this principle.

CHAP. III. Of Phlogiſticated, Dephlogiſticated or Vital, and Inflammable Air, and of the Compoſition and General Properties of Water. 92

Effects of combuſtion on common air. Obſervations and Opinions. Compoſition of the atmoſphere. Subſtances which afford vital air. Reſpiration is a proceſs of the ſame kind as combuſtion. Vegetables affect the air. Nitrous air uſed as a teſt. Subſtances which afford inflammable air. Water produced by combuſtion of vital and inflammable air. Whether water be a compound:—its extenſive utility—and general properties. Effects of the eolipile. Denſity of water. Specific gravity of water. What waters are pureſt.

CHAP. IV. Of the Simple or Primitive Earths. 99

Five primitive earths. New earths. Stones. Siliceous earth. Liquor of flints. Argillaceous earth. Earth of alum. Pottery. Wedgwood's thermometer. Calcareous earth. Lime. Mortar. Plaſter of Paris. Animal earth. Ponderous earth. Spar. Magneſia.

Magneſia. Epſom ſalt. Union of earths by fuſion. Suppoſed reduction. The new earths—of adamantine ſpar—of the Jargon of Ceylon—of a mineral from South Wales.

CHAP. V. Of the Simpler Salts; namely, Alkalis and Acids. —— 108

Characters of alkalis. Vegetable fixed alkali. Methods of procuring it. Purifying of alkalis. Alkali of nitre, called fixed nitre. Oil of tartar. Mineral alkali. Water of cryſtallization. Effloreſcence. Abundance of mineral alkali in ſea ſalt:—obtained by incineration. Turner's proceſs with common ſalt. Cauſtic ſolution of alkali:—or ſoap lees. Soap. Manufacture of ſoap in the large way. Manufacture of glaſs. Difficulties. Manufacture of ſal ammoniac. Volatile alkali:—obtained by the medium of chalk:—obtained by the medium of lime. Alkaline air. Decompoſition and formation of volatile alkali. Characters of acids. Enumeration. Mineral acids. Vegetable acids. Animal acids. Inflammable additions to acids. Theory. Neutral ſalts.

CHAP. VI. Of Metallic Bodies in general. 120

Characters of metals. Entire metals. Perfect and imperfect metals. Calces. Enumeration of metals. Regulus. Freezing point of metals. Cryſtallization. Affinities. Solder. Countries moſt abundant with metals. Ores. Veins. Mines. Matrix. Operations for extracting metals from ores. Aſſaying, or eſſaying. Humid way. Theory. Mixture of metals. Alloys. Solubility of metals in acids. Precipitation. Inferences. Original theory. New theory. Precipitation of metals by metals. Limit of ſolution in acids. Theory of ſolution. Action of various ſubſtances on metals.

SECTION II.

CONCERNING THE MINERAL ACIDS, AND OTHER MINERAL BODIES WHICH ARE CONVERTIBLE INTO ACIDS.

CHAP. I. Of Sulphur, Vitriolic Acid, and the Combinations they form with other Bodies. 129

Sulphur. Pyrites. Diſtillation of ſulphur:—ſublimation. Action of water on ſulphur. Combination of ſulphur; with

lime:

lime:—with ponderous earth:—with magneſia:—with fixed alkalis. Hepatic air. Volatile liver of ſulphur. Balſams. Combuſtion of ſulphur. Volatile vitriolic acid. Oil of vitriol. Vitriol of iron. Diſtillation of vitriol. Manufacture of vitriolic acid. Characters. Combination of vitriolic acid and clay. Preparation of alum. Vitriolic acid with lime:—with ponderous earth:—with magneſia:—with vegetable alkali:—with mineral alkali:—with volatile alkali:—with combuſtible matter. Aeriform vitriolic acid. Sulphureous acid. Characters of vitriolic acid air. Stahl's experiment for obtaining ſulphur from vitriolic acid. Electricity. Recapitulation and theory.

CHAP. II. Of the Nitrous Acid, its component Parts and Combinations. 145

Production of nitre. Nitre beds. Extraction and purification of nitre. Decompoſition by heat. Deflagration. Detonation. Invention of gunpowder:—its compoſition. Fulminating powder. Diſtillation of nitrous acid. Combination with lime:—with ponderous earth:—magneſia:—and clay:—with mineral alkali:—with volatile alkali. Production of nitrous acid:—by Mr. Cavendiſh:—by M. Thouvenel. Inference. Action of nitrous acid upon combuſtible matter. Nitrous air. Dr. Prieſtley's method of aſcertaining the reſpirability of air. Imperfections of the trial of air by nitrous air. Eudiometers. Action of nitrous acid on animal ſubſtances. Various fluids imbibe nitrous acid. Diminution of nitrous air by electricity, &c. Dephlogiſticated nitrous air. Abſorption of nitrous air by the nitrous acid. Pale nitrous acid becomes yellow by the action of light:—it is capable of the elaſtic form. Inflammation of eſſential oils by nitrous acid:—of fat oils:—of charcoal or lamp black. Recapitulation and theory. Keir's compound acid.

CHAP. III. Of the Marine Acid, and its Combinations, including Aqua Regia. 170

Salt mines and ſprings. Sea water. Extraction of common ſalt from waters. Various methods of obtaining ſalt from the waters of the ſea and ſalt ſprings. Salts contained in the ſea. Cryſtallization of common ſalt. Diſtillation of marine acid from common ſalt. Marine acid air—its corroſive nature. Salt of Sylvius. Sal ammoniac. Marine ſelenite. Homberg's phoſphorus. Argillaceous marine ſalt. Ponderous marine ſalt. Magneſian marine ſalt. Action of marine acid upon metals. Dephlogiſticated or aerated marine acid. Detonating marine ſalt:

ſalt:—with baſe of vegetable alkali:—with mineral alkali:—volatile alkali. Action of light on dephlogiſticated marine acid. Theory. The acidity of marine acid does not vary after the law of other acids. Compoſition of aqua regia. The effects and theory of aqua regia. Combinations.

HAP. IV. Of Fixed Air, Fixable Air, or Aerial Acid. — 183

ubſtances which contain fixed air. Impregnation of water. Grotto del Cano. Fixed air emitted from fermenting bodies. Experiments made in an atmoſphere of fixed air. Converſion of vegetable matter into charcoal. Production of fixed air from charcoal. Compoſition of fixed air. Opinions. The electric ſpark paſſed through fixed air. Phlogiſtic explanation. Antiphlogiſtic explanation. Combinations of fixed air:—with clay:—with calcareous earth:—with ponderous earth:—with magneſia:—with alkalis:—with combuſtible matter. Advantages derived from a knowledge of this acid.

CHAP. V. Of the Acid of Borax. 191

atural production of tincal or crude borax. Purification. Analyſis. Habitudes. Acid of borax:—found native. Analyſis of the native combination of the acid of borax with lime and magneſia. Combinations of the acid of borax with earths and alkalis. Suppoſed reduction to the metallic form.

CHAP. VI. Of the Acid of Spar. 196

uor or Derbyſhire ſpar;—its acid:—diſſolves ſiliceous earth. Etchings on glaſs. Combinations with earths, alkalis, and metals.

CHAP. VII. Of the Acid of Amber. 198

haracters of amber:—where found. Combinations of the acid of amber.

HAP. VIII. Of Phoſphorus and its Acid. 200

ative phoſphorus. Characters of phoſphorus. The diſcovery of phoſphorus; by Brandt, Kunckel, and Boyle. Defence of Boyle as the inventor. Proceſs of Boyle. Proceſs for obtaining phoſphorus from bones. Phoſphoric glaſs. Purification of phoſphorus. Phoſphoric acid, obtained by ſlow combuſtion.

buſtion. Concrete phoſphoric acid. Phoſphoric acid obtained by the action of nitrous acid : — by vitriolic acid : — b ſtrong combuſtion : — by a ſtream of vital air. Phoſphori hepar, and air. Combination of phoſphorus with ſulphur :— with oils :—ardent ſpirits :—metals. Metals revived by phoſ phorus. Uſes of phoſphorus. Phoſphoric matches. Tw ſtates of phoſphoric acid. Combinations of phoſphoric aci with earths and alkalis. Phoſphoric ſalts from urine. Micro coſmic ſalt. Perlate acid. Combinations of phoſphoric aci with metals and oils. Theory.

Chap. IX. Of the Metallic Acids; of Arſenic, o Molybdena, and of Tungſten or Wolfram. 21

Retroſpect of the facts and doctrines contained in the preſe ſection. Acidification of metals. General inferences, by co jecture. Arſenical acid. Proceſs for obtaining it. Character Combination with earths :—with alkalis. Reduction. Co bination with ſulphur. Theory. Characters of molybden Proceſs for obtaining its acid. Combinations. Regenerat molybdena. Acid of tungſten, or wolfram. Proceſs for o taining it. Characters.

SECTION III.

OF METALLIC BODIES.

Chap. I. Concerning Gold.

Characters of gold. Obvious properties. Extreme ductility a tenacity. Manufacture of gold leaf :—its thickneſs. G wire. Solvents. Aqua regia. Solution of gold. Preci tates : — by earths and alkalis : — volatile alkali. Product of fulminating gold. Analyſis. Theory. Precipitation gold by liver of ſulphur :—by metallic ſubſtances. Proceſs making the purple powder of Caſſius. Obſervations. S tion of gold in ether, &c. Gold reſiſts nitre :—but is dered pale by borax :—unchanged by earths, alkalis, or phur. Proceſs of dry parting. Combination with liver of phur :—with metals. Native ores, or alloys of gold. A ferous ſands. Pyrites containing gold. Cupellation. Sep tion of gold from the perfect metals:—by quartation:—and parting. Fineneſs of gold. The aſſay of ſmall work by the touch. Touch-needles. Obſervations on the aſſay by the touch. Aſſay of gold ores in the moiſt way. Uſes of gold.

Chap. II. Concerning Silver. 236

Characters of ſilver. Solubility in acids. Combination with nitrous acid. Lunar cauſtic. Vitriol of ſilver. Luna cornea. Malleable glaſs. Very pure ſilver obtained from luna cornea. Teſt of marine acid in waters. Purification of nitrous acid. Precipitates. Preparation of fulminating ſilver. Its effects. Precautions. Theory of the inventor. Phlogiſtic theory. Action of Keir's compound acid upon ſilver—of aqua regia. Precipitation by metals. Proceſs of Lemery for making the tree of Diana. Homberg's proceſs. Theoretical obſervations. Combinations with metals. Native ſilver and its ores. Purifying of native ſilver. Vitreous ore of ſilver. Analyſis in the moiſt way:—in the dry way. Red ſilver ore. Analyſis in the moiſt way. White ore of ſilver analyſed. Method of aſſaying ſilver, or its ores, in the dry way. Aſſay of ſilver by the touch. Extraction of ſilver from ores in the large way, by amalgamation:—by fire. Uſes of ſilver.

Chap. III. Concerning Platina. 251

Characters of platina. Crude platina. Pure platina. Welding. Solution in dephlogiſticated marine acid:—in aqua regia. Diſtinctive character. Separation of gold from platina. Malleable platina. Precipitates. Crucibles of platina. Combinations of metals. Cupellation.

Chap. IV. Concerning Mercury. 256

Characters of mercury. Precipitate per ſe. Electric light. Action of vitriolic acid. Vitriol and calx of mercury. Turbith mineral. Precipitates. Solution in nitrous acid. Nitrous turbith. Mercurial nitre. Red precipitate:—decompoſed. Precipitates. Exploſion of mercurial precipitates. Decompoſition of the nitrous ſolution by other acids. Corroſive ſublimate. Calomel. Combination of mercury with dephlogiſticated marine acid. Preparation of corroſive ſublimate. Cauſticity of metallic ſalts. Sal alembroth. White precipitate. Preparation of calomel, or mercurius dulcis. Butter of antimony. Mercurial ethiops. Cinnabar or vermilion formed in the dry way:—in the humid way. Unguents, &c. Red calx of mercury, or precipitate per ſe. Amalgams. Combinations of metals. Native mercury and its ores. Decompoſition of cinnabar. Purity of mercury. Humid analyſis of cinnabar. Uſes of mercury.

Chap. V. Concerning Lead. 268

Characters of lead. Granulated. Calcined. Minium, or red lead. Litharge and glaſs of lead. Achromatic teleſcope. Action of air and water on lead :—of vitriolic acid. Combination of nitrous acid and lead. Plumbum corneum. Action of marine acid :—acetous acid. White lead, or ceruſe. Sugar of lead. Action of liver of ſulphur on lead :—of alkalis :—oils. Habitudes in the dry way :—with phoſphoric acid. Decompoſition of ſal ammoniac :—of common ſalt. Combinations of lead with metals. Eliquation. Plumber's ſolder. Fuſible mixture. Native lead and its ores. Analyſis of calciform ores. Native ſalts of lead. Humid analyſis of phoſphoric lead ore. Sulphureous ore of lead, or galena. Analyſis of ſulphurated lead. Revival of lead by the blow-pipe. Uſes of lead.

Chap. VI. Concerning Copper. 278

Characters of copper. Solution in vitriolic acid. Nitrous ſolution of copper :—marine :—vegetable. Effect of the preſence of air. Fabrication of verdigris. Solution of copper in fixed alkalis :—in volatile alkali. Habitudes of copper with volatile alkali :—with oils, earths, alkalis, and neutral ſalts :—with ſal ammoniac :—with alum :—with ſulphur :—with phoſphorus :—with metallic ſubſtances. Bronzes and bell-metal. Metal for ſpeculums. Edwards's method of making ſpeculums. Metallic mixtures. The fabrication of braſs. Leaf braſs, or Dutch gold. Native copper, and its ores. Aſſay of native copper :—of calciform ores :—of ſulphureous ores :—in the dry way. Treatment of copper ores in the large way. Countries where copper is found. Copper applied to various uſes.

Chap. VII. Concerning Iron. 293

Characters of iron. Calcination of iron by water. Ancient theory. Modern theory. Solution in the vitriolic acid. Martial vitriol. Theory of the effects of vitriolic acid upon iron :—according to the doctrine of phlogiſten :—according to the antiphlogiſtic doctrine. Precipitates of iron. Colcothar. Black fecula, precipitated by aſtringents. Ink; its nature doubtful. Manufacture of Pruſſian blue. Pruſſian alkali. Acid of Pruſſian blue. Combinations of Pruſſian acid. Caution in uſing proof liquors. Experiments on Pruſſian acid. Theory of the effects of aërated marine acid on the Pruſſian acid. Experiment. Component parts of Pruſſian acid. Action of nitrous acid on iron. Precipitates of iron from nitrous acid. Martial alkaline tinctures. Action of marine acid on iron. Precipitates. Action of fixed

APPENDIX.

VARIOUS TABLES USEFUL TO CHEMISTS.

Page
An Account of the Tables — — — 525
Table I. The Comparative Heats of different Bodies 533
Table II. The Weights of different Countries — 534
Table III. The Specific Gravities of Bodies — 535
Table IV. The Specific Gravities of Aerial Subſtances; the Barometer ſtanding at 30 Inches, and the Thermometer at + 55° — — — — — — 536
Table V. The Expanſions of Aerial Subſtances by Heat, from the Freezing to the Boiling Points of Water. For every Interval of 20° of Reaumur's, or 45° of Fahrenheit's Thermometer — — — — — *ibid.*
Table VI. Simple Elective Attractions.—Acids — 537
Table VII. Simple Elective Attractions.—Alkalis and Earths 538
Table VIII. Simple Elective Attractions.—Combuſtible Subſtances and Water — — — — 539
Table IX. Simple Elective Attractions.—Phlogiſton and Metals — — — — — 540
Table X. Simple Elective Attractions.—Metallic Subſtances 541
Table XI. Simple Elective Attractions.—Metallic Subſtances 542
Table XII. Numerical Expreſſion of Attractions by M. Morveau — — — — — 543
Table XIII. Of the Proportion of Ingredients in Earths and Stones.—Calcareous Genus.—Barytic or Ponderous Genus.—Muriatic or Magneſian Genus.—Argillaceous Genus.—Siliceous Genus.—Proportion of Ingredients in Natural Salts *ibid.*
Index — — — — 547

EMENDATIONS AND ADDITIONS.

I HAVE not obſerved any error of the Preſs but ſuch as the ſenſe of the context will obviouſly tend to rectify.

In the Chapter on Nitrous Acid I have omitted to inſert an account of the very important diſcovery of the Rev. Iſaac Miner, B.D. F.R.S. inſerted in the LXXIXth vol. of the Philoſophical Tranſactions. This gentleman, finding, as well from his own experiments as thoſe of others, that volatile alkali is afforded in various inſtances of the application of nitrous acid to metals (ſee page 336 of the following treatiſe), was almoſt immediately ſtruck with the notion, that the proceſs might be inverted. That is to ſay, as the phlogiſticated air of nitrous acid, when made to combine with inflammable air, affords volatile alkali; ſo, on the contrary, if vital air could, by any effect of the chemical affinities, be made to engage with the phlogicated air of volatile alkali, while the other principle, namely, the inflammable air, ſhould be either retained or diſengaged, the reſult of ſuch an engagement or combination would be the nitrous acid in ſome of its modifications. For this purpoſe, he crammed a gun-barrel full of manganeſe in coarſe powder, which ſubſtance is known to afford vital air by heat, and to one end of this tube he applied a retort containing the cauſtic volatile alkali. Heat was then applied to the gun-barrel, and, as ſoon as it was ignited, he placed a candle beneath the retort, which cauſed the volatile alkali to boil, and paſs through the gun-barrel in the form of alkaline air: the conſequence was, that nitrous air was emitted at the other end of the tube.

He likewiſe repeated the experiment with ſucceſs; uſing martia vitriol calcined to whiteneſs, inſtead of manganeſe. The whol paper is highly deſerving the attention of chemiſts.

In the fourth Chapter of the firſt Book of this Work I had obſerved in a note, that very complete ſets of ſmall apparatus for experiments with the blow-pipe, and with ſmall retorts and receivers, were ſold in London, under the inſpection of Mr. Magellan, by Brown, Bookſeller, Eſſex-ſtreet, in the Strand. The death of that worthy and active philoſopher induced me to cancel the note in the preſent Edition; but as Mr. Brown has ſince acquainted me that he has a conſiderable number of ſets remaining, I think I ſhall do a ſervice to the chemical ſtudent by repeating the information in this place.

air and vinegar. Action of earths, &c. on iron. Combination with ſulphur, in the humid way. Spontaneous inflammation. Theory of the inflammation of iron and ſulphur: — by the antiphlogiſtic hypotheſis. Union of ſulphur with iron in the dry way, Phoſphorus and iron. Cold ſhort iron. Siderite. Metallic combinations. Tinning of iron plates. Combinations of iron with metallic ſubſtances. Native iron and its ores. Humid analyſis of iron ores. Analyſis in the dry way. Smelting of iron in the large way. States of iron. The three kinds of crude iron. Refining of iron. Bar iron. Iron converted into ſteel by cementation. The proceſſes for hardening and tempering of ſteel. Caſt ſteel. Compariſon of ſteel and crude iron. Conſideration of the effects of heat in refining iron. Probable cauſe of the property of welding. Proceſſes for refining crude iron, and making ſteel in a direct way. The exiſtence of plumbago in crude iron and ſteel; aſcertained in the dry way. Plumbago extricated from iron in the humid way. Quantities of plumbago and of inflammable air afforded by various kinds of iron. Degrees of reduction and cementation in iron. Inaccuracies. Characters of plumbago:—habitudes. Experiments tending to diſcover the component parts of plumbago. Phlogiſtic theory, Antiphlogiſtic theory of plumbago. Reſemblance between plumbago and pyrites. Recapitulation of the facts relating to the ſtates of iron. Uſes.

Chap. VIII. Concerning Tin. 334

Characters of tin. Solution in vitriolic acid:—in nitrous acid. Singular effect. Volatile alkali produced from nitrous acid, &c. Solution of tin in marine acid:—in dephlogiſticated marine acid: —in aqua regia. Acid of tin. The fuming liquor of Libavius. Adet's examination of the fuming liquor. Habitudes of tin with earths and neutral ſalts: — with ſal ammoniac. Spontaneous decompoſition and inflammation of metallic ſalts. Combination of tin with ſulphur. Aurum muſivum. Combination of tin with phoſphorus. Metallic mixtures. Pewter. Miſtake of foreigners reſpecting Engliſh tin. Native tin. Calciform ores of tin. Tin ores containing arſenic and ſulphur. Proceſs of elutriation deſcribed and explained. Putty. Analyſis of tin ores, in the humid way:—in the dry way. Reduction of tin in the large way. Countries which afford this metal. Uſes.

Chap. IX. Concerning Biſmuth. 349

Characters of biſmuth. Action of vitriolic acid. Solution in nitrous acid. White calx or magiſtery of biſmuth. Solution in marine acid. Habitudes with earths, ſalts, ſulphur, and metallic ſubſtances. Uſes. Native biſmuth and its ores.

Chap. X. Concerning Nickel. 353

Characters. Treatment of the ores of nickel. Pureſt regulus of nickel :—is an entire metal. Action of vitriolic acid. Whether nickel be truly a peculiar metal.

Chap. XI. Concerning Arſenic. 356

Characters. White calx of arſenic :—is in a ſaline ſtate. Regulus. Action of vitriolic acid : — of nitrous acid : — of marine acid :—of aërated marine acid. Diſtillation of calx of arſenic with ſulphur. Orpiment and realgar. Liver of ſulphur. Combination of calx of arſenic with alkalis :—with metals. Action of arſenical acid on metals. Combinations of regulus of arſenic. Uſes of arſenic.

Chap. XII. Concerning Cobalt. 366

Characters of cobalt. Combination with vitriolic acid : — with nitrous acid : — with marine acid :—with aqua regia. Sympathetic ink. Acid of borax and cobalt. Acid of ſugar. Habitudes of cobalt : — with nitre : — with ſal ammoniac : — with ſulphur : — with metallic ſubſtances. Native cobalt and its ores. Humid analyſis. Analyſis in the dry way. Cobalt found moſt plentifully in Saxony. Manufacture of zaffre and ſmalt. Uſes of cobalt.

Chap. XIII. Concerning Zinc. 372

Characters of zinc. Solution in vitriolic acid. White vitriol. Solution of zinc in nitrous acid :—in marine acid. Habitudes with vitriolic ſalts : — with nitre : — with common ſalt, ſal ammoniac, and alum :—with ſulphur :—with liver of ſulphur : —with metals. Native zinc and its ores. Humid analyſis Eſſay of calamines. Diſtillation of zinc. Spelter. Uſes.

Chap. XIV. Concerning Antimony. 378

Characters of antimony. Action of vitriolic acid .—nitrous acid —marine acid :—dephlogiſticated or aërated marine acid :— aqua regia. Habitude of regulus of antimony with earths :— with vitriolated tartar. Detonation with nitre. Diſtillation o the regulus with corroſive ſublimate. Butter of antimony Theory. Powder of algaroth. Bezoar mineral. Combinatio of regulus of antimony with ſulphur :—with liver of ſulphu Crude antimony : — its habitudes : — by heat : — with acid Diaph

Diaphoretic antimony. Antimonial medicines. Kermes mineral. Emetic wine. Antimoniated tartar. Medical effects of antimony. Perpetual pills. Native antimony and its regulus. Humid analyſis. Dry way. Uſes.

CHAP. XV. Concerning Manganeſe. 386

aracters of manganeſe. Action of vitriolic acid. Black calx of manganeſe. Theory. Solution of the regulus in nitrous acid:—in marine acid. Combinations of calx of manganeſe in the dry way. Explanation of the changes of colour in glaſſes which contain manganeſe. Theories. Combination with ſulphur. Metallic combinations of manganeſe. Native manganeſe and its ores. Humid analyſis. Spontaneous inflammation of black wadd. Reduction of manganeſe. Speedy calcination. Uſes.

CHAP. XVI. Concerning Wolfram. 394

aracters and habitudes of the calx and regulus of wolfram.

CHAP. XVII. Concerning Molybdena. 396

aracters of regulus of molybdena. Habitudes with various ſubſtances. Diſtinctive characters.

HAP. XVIII. Concerning Uranite, or Uranium. —— —— 398

eſcription of pitch-blende. Habitudes with fire:—with acids. Yellow calx. Reduction.

SECTION IV.

F MINERAL COMBUSTIBLE BODIES, AND THE DIAMOND.

HAP. I. Of Mineral Combuſtible Bodies. 401

numeration. Petroleum. Barbadoes tar. Aſphaltum. Mineral tallow. Jet. Pit coal. Peat. Turf. Amber. Sulphur. Plumbago. General obſervations on the combuſtible ſubſtances found in the mineral kingdom.

CHAP. II. Concerning the Diamond. 40

Characters, &c. of the diamond. Hardneſs and brilliance of dia
monds:—ſoluble in vitriolic acid:—combuſtible. Coloure
diamonds.

SECTION V.

CONCERNING THE PRODUCTS OF THE VEGETABL KINGDOM.

CHAP. I. Of the Structure and Component Par
of Organized Subſtances. 40

General obſervations. The parts of organized bodies conſtitu
apparatus for performing chemical operations. Vegetable bodi
Animal bodies. Secretions or combinations of vegetable a
animal ſubſtances. Nutrition. Diſeaſe. Death. Vario
methods of ſeparating the parts of animal or vegetable ſu
ſtances. Vegetable products arranged.

CHAP. II. Concerning ſuch Principles of Veg
tables as do not exhibit Saline Properties, and a
obtained without the Application of any great
Heat than that of Boiling Water, and witho
the Action of any Solvent but Water or Arde
Spirit. — — 4

Enumeration of ſuch principles of vegetables as are not ſali
Juices or extracts. Mucilage or gum. Sugar. Manufact
of ſugar. Manufacture of flour, or the powder of farinace
ſeeds. Starch. Vegetable gluten. Fat oils. Volatile or eſ
tial oils. Camphor. Reſinous ſubſtances. Principle of ſmel
vegetables. Colouring matters. Art of dying. Lakes.

CH

CHAP. III. Concerning the Saline Principles of Plants obtained by Preſſure, or by the Application of Water or Ardent Spirit; particularly the Acids of Lemons, of Apples, of Nut-Galls, and of Benzoin. — — 415

Mineral ſalts found in vegetables. Peculiar ſalts enumerated. Various methods of preſerving lemon-juice:—by oil:—by evaporation:—by freezing. Depuration of the acid of lemons: —by congelation:—by the chemical affinities. Characters. Method of purifying the acid of apples. Separation of the acids of lemons and of apples. Acid of apples. Characters. The aſtringent principle, or acid of galls:—obtained in ſolution:—in the cryſtallized form. General characters and habitudes of the acid of galls. Benzoin:—its acid obtained by ſublimation, and in the humid way:—its characters.

CHAP. IV. Concerning the Acids of Tartar and of Sorrel. — 437

Tartar. Cream and cryſtals of tartar. Characters of purified tartar. Habitudes. Soluble tartar. Curious fact reſpecting ſolubility. Manufacture of Rochelle ſalt. Ammoniacal ſalt of tartar. Method of obtaining the acid of tartar:—its characters and habitudes. Salt of ſorrel:—its characters, and action upon various ſubſtances. Method of purifying the acid of ſorrel. Characters. Combinations.

CHAP. V. Concerning the Vegetable Acids produced or developed by Deſtructive Diſtillation, or by the Action of Nitrous Acid. — 445

Conſiderations on the compoſition and decompoſition of vegetable bodies. Simplicity and ſmall number of vegetable principles. Empyreumatic acids. Empyreumatic acid of tartar:—of ſugar or mucilage:—of wood. Obſervations on the effect of nitrous acid upon vegetable bodies. The progreſs of acidification in vegetable bodies. Difference between the acids of ſugar and ſorrel. The proceſs for converting ſugar into an acid. Obſervation. Acid of camphor. Acid of cork.

CHAP. VI. On the Deſtructive Diſtillation of Vegetable Subſtances. — 452

Deſtructive diſtillation. Decompoſition of vegetables by fire. Empyreumatic oils. Charcoal:—conducts electricity:—reſiſts heats,

heats, and abſorbs elaſtic fluids:—exceedingly combuſtible:—ſolubility:—revivification. Obſervation. Reſidual ſalts.

CHAP. VII. Concerning Fermentation in general. — 457

The ſpontaneous decompoſition of vegetables. Three ſtages of fermentation: — vinous: — acetous: — putrid. Conditions of circumſtances requiſite to the progreſs of fermentation. Vinous fermentation deſcribed, as it takes place in ſugar and water. Yeaſt. Inflammable ſpirit. Acetous fermentation. Putrefaction. The effect of yeaſt in fermentation. Component parts of ardent ſpirit, &c. Tartar. Bread.

CHAP. VIII. Concerning Vinous Fluids and Ardent Spirit. — 463

The making of wine from grapes. The malting of barley:—of Indian corn. Brewing of beer. Metheglin and koumiſs. Product of vinous liquors by diſtillation. Reſidue. Strength of ardent ſpirit determined by M. Bories. Specific gravities of various mixtures of water and ſpirit. Obſervations. Strongeſt ardent ſpirit by mere diſtillation. Requiſites or deſiderata to aſcertain the ſtrength of ſpirit. Phial proof. Proof by burning. Characters and component parts of ardent ſpirit: — its uſes and combinations. Mutual action of ardent ſpirit and ſalts:—and ſulphur:—and earths.

CHAP. IX. Concerning thoſe Inflammable Fluids which are produced by the Action of Acids upon Spirit of Wine, and are known by the Name of Ether. — — — 472

Diſtillation of vitriolic ether. Rectification. Characters. Solubility in water. Combinations of vitriolic ether. Methods of preparing nitrous ether. Characters. Method of preparing marine ether. Acetous ether. Ligneous ether. Saccharine ether. Phoſphoric ether. Ether produced by acid of ants:—by acid of benzoin. General obſervations.

CHAP. X. Concerning the Acetous Acid. 482

Crude vinegar. Diſtilled vinegar, or acetous acid. Concentration by froſt. The moſt advantageous method of concentrating vinegar. Combinations of acetous acid: — with argillaceous earth: — with calcareous earth: — with magneſia: — with vegetable alkali. Foliated earth of tartar. Radical vinegar. Combi-

Combinations of acetous acid: — with mineral alkali: — with volatile alkali: — with gold: — with ſilver: — with mercury: with lead: — with copper: — with iron. Metallic combinations. Zinc an improper material to defend copper veſſels.

SECTION VI.

CONCERNING THE PRODUCTS OF THE ANIMAL KINGDOM.

CHAP. I. A Short Enumeration of ſuch Animal Subſtances as have been examined by Chemiſts. — — — 489

Analyſis and arrangement. Enumeration.

CHAP. II. Concerning Milk, Eggs, Honey, Wax, Lacca, Silk, Hair, Horn, &c. 491

General characters of milk. Effects of heat on cows milk. Fermentation of milk. Cream. Butter. Acid of milk. Its combinations with various ſubſtances. Curd. Manufacture of cheeſe: — its properties. Sugar of milk: — decompoſed by heat: — treatment with nitrous acid. Peculiar acid of ſugar of milk. Combinations. Separation of butter from cream: — its properties. Eggs. Reſemblance between white of egg and curd of milk. Yolk of egg. Honey and wax. Purification of honey. Diſtillation of wax. Butter of wax. Bleaching. Difference between wax and tallow. An explanation of the chief advantage of wax candles compared with thoſe of tallow. The uſe and effects of the wick in candles. Stick-lac, ſhell-lac, and ſeed-lac: — its production: — purification: — characters. Hard varniſh. Uſes of lac. Silk, and the acid of ſilk-worms. Animal excreſcences.

CHAP. III. Concerning the Excrementitious Parts of Animals. — 506

Urine and fecal matter. Stone of the bladder. Acid of the ſtone of the bladder. Homberg's experiments on human excrement. Ambergris; — its characters. Matter of perſpiration, &c.

CHAP. IV. Concerning the Blood, and the other Fluid or Solid Matters of which Animals are formed. — — — 510

Characters of the blood. Habitudes with acids, &c. Diſtillation. Serum of blood:—reſembles white of egg, curd, and vegetable gluten:—habitudes with alkalis and acids:—with ardent ſpirit:—with nitrous acid. Craſſamentum, Fibrous part of blood:—with acids. Deſtructive diſtillation. Soft parts of animals. Jelly or glue. Analyſis of the fleſh of animals. Animal fat:—its acid:—characters. Method of obtaining ſpermaceti. Its characters and habitudes. Conjecture reſpecting its ſingular properties. Bones:—their white reſidue.

CHAP. V. Concerning the Bile, the Gaſtric Juice, and the Acid obtained from Ants. 520

Characters of the bile, or gall. Deſtructive diſtillation of the bile. Biliary concretions. The gaſtric fluid. Acid of ants.

BOOK I.

GENERAL CHEMISTRY.

CHAP. I.

GENERAL OBSERVATIONS ON CHEMISTRY, AND THE MEANS BY WHICH ITS OPERATIONS ARE PERFORMED

GENERAL OBSERVAT.

Chemiſtry defined.

CHEMISTRY may be conſidered either as a ſcience or an art. As a ſcience, its object is to eſtimate and account for the changes produced in bodies by motions of their parts which are too minute to affect the ſenſes individually. As an art, it conſiſts in the application of bodies to each other, in ſuch ſituations as are beſt calculated to produce thoſe changes.

Analyſis.

Syntheſis.

The operations of chemiſtry are either analytical, when compounded bodies are reſolved into their ſimpler parts; or ſynthetical, when ſimple bodies are united ſo as to form a compound. The former operation is called decompoſition; and the latter compoſition, or combination. There are few, and perhaps no chemical proceſſes, in which one of theſe effects takes place without the other.

Heat expands ſolids, then renders them fluid, and afterwards converts them into vapour; and theſe

GENERAL OBSERVAT. Heat.

changes ſucceed each other as the intenſity of the hea is rendered greater. There are many bodies not ſuſceptible of all theſe changes: but it is highly probable that this is owing to our want of power to produce a ſufficient degree of heat or coldneſs, and not to the peculiar nature of the bodies themſelves.

Analyſis by heat. The heat required to render different bodies fluid or elaſtic, being different, affords a method of ſeparating the parts of compound bodies. If one part o a compound body be rendered fluid, while the other remain ſolid, the former will flow into the lower par of the containing veſſel, and leave the pores of th latter empty: or if one part be converted into vapour, it will riſe and fly off, leaving the other parts, whether ſolid or fluid, in the veſſel. Thus when mixture of lead and copper is expoſed to a gradu heat, the lead melts firſt, and leaves the copper. An if a mixture of water and ſalt be heated, the wat being converted into vapour, flies off, and leaves th ſalt behind.

Attraction. All the parts of bodies attract each other. It is n neceſſary in this place to enquire, whether that attra tion which cauſes bodies to gravitate or have weigh and by the energy of which the great motions of t planetary ſyſtems are governed, be the ſame as the a traction which cauſes their parts to adhere, and giv them firmneſs or ſolidity. It is enough that obſ vation has not yet eſtabliſhed the truth of this pr poſition; and, conſequently, it will be proper to co ſider the attraction that is perceived to obtain chemical operations, as a diſtinct property of matter

The attractions which are obſerved in chemiſt are not found to have efficacy at any ſenſible diſta

betw

Chemical attractions

etween the parts; but doubtleſs, like the attractions f gravity, magnetiſm, and electricity, they are ſtronger he leſs the diſtance. The rigidity and permanent orms of ſolid bodies prevent many of the parts of two everal bodies from coming near each other: for which eaſon, very little change is in general produced by heir mutual action, even in the moſt favourable caſe, vhen powders are mixed together. But when one r both of the bodies is heated ſo as to become fluid, he particles eaſily move among each other, and can nore readily obey the attractions which exiſt between hem. Hence it has been conſidered as a chemical xiom, that bodies do not act on each other, unleſs one f them be fluid.—This aſſertion is liable however to he exception, that ſolid bodies will combine at a temerature too low to render either of them fluid, proided it be high enough to fuſe the compound they form. Thus ice and ſalt will combine at a much lower temperaure than would liquefy either alone, if the temperature e not ſo low as to freeze the brine they form by uniting.

—act by means of heat

Art of the chemiſt.

The whole art of the chemiſt therefore conſiſts, ither in ſeparating the parts of bodies by the appliation of heat, or in placing them ſo that the order of rrangement of their parts may be changed by virtue f their ſeveral attractions, aſſiſted by heat ſufficient to uſe one or more of them, or at leaſt ſufficient to produce fuſion in the compound.

Elective attractions.

Since the order of arrangement of the parts of bodies is changed, when the chemical attractions are permitted to act, by a due ſituation of bodies with reſpect to each other; it clearly follows, that the attraction between ſome kinds of bodies is ſtronger than between others.

others. This difference was formerly ſuppoſed to procee from a ſimilitude between the attracting bodies, and f that reaſon the attraction has been called the chemic affinity of bodies. But the term elective attraction at preſent more generally uſed to denote this propert

Dry and humid way.

Though the operations with bodies that require very ſtrong heat to render them fluid, do not eſſe tially differ from thoſe which are made with ſuch b dies as are fluid at the uſual temperature of the a moſphere; yet, as the apparatus for producing an maintaining the heat in the former caſe is unneceſſa in the latter, it is found convenient to diſtinguiſh t two methods by different appellations. Operatio made with bodies habitually ſolid, which of cour require to be acted on by a ſtrong heat, are ſaid to made in the dry way; but operations wherein a ſubſtance is employed which is habitually fluid, a ſaid to be made in the liquid, humid, or moiſt wa No diſtinctive appellation has yet been generally a opted for operations made with elaſtic fluids; thou ſome call this the pneumatic method.

Terms of art.

In every ſcience or art there are many things whi require to be frequently mentioned. If theſe we deſcribed as often as they are mentioned, it is obvio that a great loſs of time would follow; and no adva tage would be gained in perſpicuity, becauſe theſe ſcriptions would continually divert the mind from leading object. For this reaſon it is abſolutely nec ſary to expreſs ſuch things by ſingle words or ter which, when once underſtood, may always afterwa be uſed in the ſame ſenſe. Theſe will be explained following treatiſe as they occur.

C H A

CHAP. II.

ON HEAT.

HEAT.

Of the word heat.

THE ſenſations expreſſed in common language by the words heat and coldneſs, are of too ſimple a nature either to require or to admit of definition. Theſe words, however, are not always uſed to denote the ſame things; but are indiſcriminately applied both to the ſenſation itſelf, and to that which cauſes it. Thus we ſay that we ourſelves are hot or cold, and that the fire or ice which heats or cools us is likewiſe hot or cold, though the ſenſations we experience are certainly very different things from that which enables bodies to excite them. It may alſo be remarked that, in this ambiguous manner of ſpeaking, there is another cauſe of uncertainty, that ariſes from the uſe of a variable ſtandard of compariſon. Every one knows that the eſtimate of heat or coldneſs differs in various perſons, becauſe each forms his judgment from his own ſenſations: and the ſame body may appear hot to one perſon, and cold to another, or to the ſame perſon at different times; though the variation is not in the body itſelf, but in the ſtate of the perſons in whom thoſe ſenſations are excited. Hence it appears neceſſary, in order to avoid error in the purſuit of enquiries concerning heat, that the ſenſe of the words made uſe of ſhould be accurately defined; and that ſome fixed ſtandard of compariſon be referred to inſtead of the human body, which, though fixed enough for the common affairs of life, is certainly not enough ſo for the purpoſes of ſcience.

Word heat.

The word heat, in a philoſophical ſenſe, is uſed to denote the cauſe of the power which bodies poſſeſs of exciting the ſenſations of heat or coldneſs.

Temperature.

The word temperature denotes the ſtate of the body with reſpect to that power. So that a body which excites a more intenſe ſenſation of heat or coldneſs than another body, is ſaid to poſſeſs a higher or lower temperature.

Cauſe of temperature.

It has not yet been determined in what heat itſelf, or the cauſe of temperature, conſiſts. Two opinions have long divided the ſcientific world. One is, that heat conſiſts of a peculiar motion or vibration of the parts of bodies, ſo that the temperature is higher the ſtronger the vibration: the other is, that heat is a ſubſtance or fluid, whoſe greater or leſs quantity produces a higher or lower temperature. Though the deciſion of this great queſtion is highly deſerving o the attention of philoſophers, yet it will not be neceſſary to conſider its merits in this place; and tha more eſpecially, as the doubts reſpecting it will not impede our reaſoning concerning ſuch phenomena as are well known. For ſince effects are proportioned to their adequate cauſes, we may ſpeak of the quantitie of heat in bodies, without deciding whether they b quantities of motion or quantities of matter; the relations of thoſe quantities to each other, and not thei peculiar nature, being the chief object of our reſearch.

Common temperature.

Two bodies which, when in contact, neither impar nor receive heat from each other, are of the ſame tem

perature

perature. All bodies, therefore, which by direct or ſucceſſive contact communicate with each other, muſt either have the ſame temperature, or the hotter will communicate heat to the others, till a common temperature is produced amongſt them.

Conductors of heat.

The diſpoſition or power of quickly tranſmitting heat in the production of a common temperature, is not the ſame in different bodies. If a number of ſtraight wires of equal ſizes, but different metals, be covered each with a thin coat of wax, and their ends be all plunged in the ſame heated fluid—for example, melted lead—the fuſion of the coat of wax will ſhew that heat is more quickly tranſmitted through ſome metals than others. Thus alſo it is found, that the end of a glaſs rod may be kept red-hot for a very long time, without any inconvenience to the hand which holds the other end; though a ſimilar metallic rod, heated in the ſame manner, would very ſoon become too hot to be held. Bodies that quickly alter their temperature by communication, are ſaid to be better conductors of heat than ſuch as alter more ſlowly.

Solid, fluid, and vaporous ſtates.

The general effects of a change of temperature are theſe:—A ſolid is rendered fluid by an increaſe of temperature, and a ſtill greater increaſe converts it into elaſtic fluid or vapour. If the body be compoſed of parts which become ſolid, fluid, or vaporous, at different temperatures; and the elective attraction by which thoſe parts are held together be inſufficient to prevent their aſſuming thoſe ſtates by the change of temperature, a ſeparation will then take place: thus a diminiſhed temperature ſeparates many ſalts from water, by their becoming ſolid; and an increaſed temperature ſe-

Expanſion by heat.

parates water from ſalts, by cauſing the former to fly off in vapour. Laſtly, if neither the change of temperature be conſiderable enough to alter the ſtate of ſolidity, fluidity, or vapour, which the body under conſideration may happen to poſſeſs; nor the body itſelf be of that nature as to undergo a ſeparation of its parts by the change; then an increaſe of temperature will cauſe an increaſe in the bulk or dimenſions of the body, which will laſt no longer than during the time of the increaſe.

Changes by heat do not follow the denſity, &c. of bodies.

Irregularities.

It has already been obſerved, that the temperature at which different bodies change their form, is various. Neither this property, nor the expanſions of bodies by heat, have been obſerved to have any correſpondence with their denſity, hardneſs, ſpecific gravity, or other evident properties. There are likewiſe ſome irregularities in the contraction or expanſion, which depend on circumſtances not yet well aſcertained, near the freezing point of water, and probably other ſubſtances. Pure water, when cooled, is obſerved to contract till within about 8 degrees of the freezing temperature, where it begins to expand; and it may be cooled 11° below that temperature, and ſtill continue fluid. An adequate explanation of the circumſtances that attend the converſion of bodies from their ſeveral ſtates, of ſolidity, fluidity, and vapour, ſeems to promiſe a more intimate acquaintance with the nature and properties of the particles of bodies than has hitherto been obtained.

Elaſtic fluids.

Permanently elaſtic fluids, or airs, appear to differ from vapour in the circumſtance that they take and retain the elaſtic form at a lower temperature. There

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are facts which render it probable, from analogy, that a great degree of cold would convert them into denſe fluids.

Quantity of heat in equal bodies:

It is a ſelf-evident truth, that if two bodies be perfectly equal and alike in all reſpects, and have the ſame temperature, they will poſſeſs equal quantities of heat. Thus, a pound of gold will poſſeſs an equal quantity of heat with another pound of gold, at the ſame temperature; a pound of water will poſſeſs an equal quantity of heat with another pound of water, at the ſame temperature; and ſo forth. From this it will alſo be clear, that two pounds of gold will poſſeſs twice as much heat as one pound of gold, at the ſame temperature; and, generally, that the quantities of heat in bodies of the ſame kind, and at the ſame temperature, will be in proportion to their quantities of matter or their weights.

—differing in temperature

If two ſuch equal and ſimilar bodies, that differ in temperature, be brought together, they will by communication acquire a common temperature, and their quantities of heat will by that means be rendered equal. For this purpoſe it is clear that the hotter of the two bodies muſt have communicated half its exceſs to the colder: the quantity of heat in one of theſe two equal bodies will therefore be an arithmetical mean between the two quantities originally poſſeſſed by each of them; that is to ſay, its temperature, or the common temperature, will exceed that of the colder exactly as much as it falls ſhort of that of the hotter body.

— in unequal bodies.

If the two bodies had been unequal, they would nevertheleſs have acquired a common temperature by communication, but the exceſs of heat would not have been

been equally divided between them; for we have ſhewn that the quantities of heat in ſuch bodies, at the ſame temperature, are in proportion to the quantities of matter. If the ſurplus of heat had been entirely taken away, it is obvious that their temperatures would have been made equal, and their heats would have been in that proportion; and there is no other way of adding the ſurplus to them, ſo as to preſerve the ſame proportion, but by giving more to the larger than to the ſmaller body, according to its quantity. The common temperature they acquire ſhews that this is done; and conſequently that, when two unequal bodies of the ſame kind acquire a common temperature by communication, the exceſs of heat in the hotter body is divided between them in proportion to their weights or quantities of matter.

Quantities of heat required to change temperature.

From this it is likewiſe evident, that the quantities of heat required to be added to or taken from bodies of the ſame kind, to produce equal changes in their temperature, will be in proportion to their quantities of matter.

Thermometer;

—its requiſites.

The foregoing deductions naturally lead us to th conſideration of an inſtrument proper to ſhew the temperatures of bodies. Such an inſtrument will require to be placed in contact with the body unde examination, in order that it may acquire the ſam temperature. It is therefore an indiſpenſable condition, that the inſtrument ſhould be of that ſmall bul as not ſenſibly to heat or cool the body it touches; bu that the common temperature of the inſtrument, an the body itſelf upon contact, may, without perceptibl error, be taken for the original temperature of th

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body. Another condition equally requiſite is, that every change of temperature ſhall be attended with ſome evident change in the inſtrument by which it may be aſcertained. The expanſions and contractions of bodies are the moſt convenient for this purpoſe. Theſe, however, are ſmall; and would require to be magnified by ſome mechanical or optical contrivance, if a ſolid body were made uſe of. But the ſmalleſt change in the bulks of fluids may be eaſily ſhewn by the happy expedient of including them in a bottle whoſe neck is long, and very narrow, in proportion to the diameter of its body. On theſe conſiderations the thermometer is made. It conſiſts of a glaſs ball or bottle, with a long narrow tube or neck, and is partly filled with mercury; a fluid preferable to all others, from its unchangeableneſs, the regularity of its expanſions, and its not ſoiling the tube. The expanſions or contractions of the mercury are ſhewn by the riſe or fall of its ſurface, which is meaſured by a graduated ſcale uſually fixed to the tube.

Mercurial thermometer.

The determination of the correſpondence between the degrees of the thermometer, and the actual variations of the heat of fluids, was firſt accurately determined by Mr. De Luc. By mixing equal quantities of water at different temperatures, he found that the thermometer very nearly indicated the arithmetical mean between the two temperatures, and conſequently that its indications are ſuch as truly correſpond with the quantities of heat.

Correſpondence of the expanſions of mercury with the increments of heat aſcertained by De Luc;

As theſe fundamental experiments cannot be too ſtrictly examined, the following doubt remained to be conſidered, namely, whether the diſpoſition to give out or

—By Crawford.

HEAT.

or to receive heat, were the ſame in water at all temperatures; becauſe it is clear that, if this diſpoſition be changed by heating or cooling, the temperature, or power to heat or cool other bodies, will not follow the ſame proportion as the quantities of heat; though it may be imagined, not without probability in this caſe, that correſpondent irregularities in the expanſions of the mercury, may cauſe the thermometer to indicate the arithmetical mean between the two expanſions produced by any extreme temperatures. But whatever irregularities may be ſuppoſed to counteract each other in theſe experiments with mercury and water, it is to the laſt degree improbable that the ſame compenſation would be found, when the mean temperature is obtained by other methods. With this view the celebrated Dr. Crawford * very carefully repeated and confirmed Mr. De Luc's experiments; made others with a like reſult, by uſing linſeed oil inſtead of water, and alſo by producing the mean temperature, permanently, in air included in a cylinder formed of two equal parts, the upper of which was kept to the freezing point, by ſurrounding it with pounded ice; and the lower to the boiling-water point, by ſurrounding it with a greater ſupply of ſteam than could be condenſed by its contact. The near correſpondence of theſe ſeveral methods ſhews that the expanſions of the mercury in the thermometer are correſpondent with the heat it receives.

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* On Heat. London, 1788. This moſt valuable performance contains the theory, and moſt of the facts, relating to heat; and deſerves to be made a part of the library of every natural philoſopher.

Thus

Quantities of heat in bodies of different kinds: —relative.

Thus far we have attended only to the communication of heat between bodies of the ſame kind; but when two equal bodies of different kinds produce a common temperature by communication, it ſeldom happens that it proves to be an arithmetical mean between the two original temperatures. In ſuch caſes it is evident that the heat which was communicated from one to the other, has not altered their temperatures equally, but has raiſed or lowered that of the one more than it has lowered or raiſed that of the other. And as the proportion between the number of degrees through which one of two bodies is thus raiſed, and the other lowered, is found by experiment to be the ſame, however different the two original temperatures may have been, provided no change of form or chemical combination has been produced in either of them; it is a general conſequence, that the quantity of heat required to alter the temperature of one of the bodies a ſingle degree, or any other equal part, will be greater or leſs than would be required to produce the ſame change in the other body, in proportion as the changes produced by the communicated heat were leſs or greater.

—abſolute.

The whole heat in each body, when they have the ſame temperature, muſt conſiſt of the ſame number of degrees: the proportion between the whole heats of the bodies will therefore be the ſame as between the heats required to raiſe each of them a ſingle degree: that is to ſay, the comparative heats of bodies, at the ſame temperature, will be in the inverſe proportion of the number of degrees their temperature is altered by the ſame quantity of heat.

Example.

To illuſtrate this by an example in round numbers

Suppoſe

Suppoſe a pint of mercury, at the temperature of 136°, be mixed with a pint of water at 50°, the mean temperature will be 76°. The water therefore has been heated 26°, and the mercury has been cooled 60°, by the loſs of the heat it imparted to the water. The abſolute heat in one degree of the mercury will conſequently be proportionally leſs than that of one degree of the water; becauſe the very ſame heat which has raiſed the water 26 degrees in temperature, would raiſe the mercury ſixty, if it could be returned again: and the whole heat contained in the mercury will be to that of the water in the ſame proportion of 26 to 60. But in the preſent experiment equal bulks were uſed; and mercury is about 13 times as heavy as water. An equal weight of mercury would contain only one-thirteenth part of the heat. Twenty-ſix, divided by 13, quotes 2: whence the comparative heats of mercury and water are in the proportion of about 2 to 60, or 1 to 30; that is to ſay, a pound of mercury, at the ſame temperature, contains no more than one-thirtieth part of the heat contained in a pound of water.

Comparative heat.

It may be obſerved that the term comparative heat is uſed to denote the proportion of the abſolute quantity of heat in one body to that of another equal maſs of matter at the ſame temperature, conſidered as a ſtandard. The ſtandard made uſe of is pure water, in a fluid ſtate. Some writers call this ſpecific heat. The diſpoſition, or property, by which bodies ſeverally require more or leſs heat to produce equal change in their temperature, is called their capacity for heat.

Capacity.

Theſe capacities are conſidered as the unknown cauſe of the differences in their comparative heats, to which they are conſequently proportional.

Capacities in various ſtates.

It is found, by experiment, that the capacity of the ſame body for heat is leaſt when ſolid, greater when fuſed or fluid, and greateſt of all when it becomes converted into vapour, or elaſtic fluid.

—changes by chemical actions.

Alſo, when bodies unite by virtue of chemical attraction, their capacities are ſeldom the ſame as the ſum of the capacities of the bodies, but almoſt always either greater or leſs.

Inferences.

As the experiments relating to the capacities of bodies cannot be here given at large, it will be proper to mention, by way of inference, ſome of the chief conſequences of this moſt luminous doctrine; firſt premiſing, however, that theſe inductions have all been verified by experiment*.

Ice and water.

The capacities of ice and fluid water are found to be as 9 to 10. Ice cannot therefore be converted into water, unleſs it be ſupplied with as much heat as is ſufficient to anſwer the difference of capacity. Thus, if equal quantities of ice and water, both at the temperature of 32°, or the freezing point, be expoſed in ſimilar veſſels, at the ſame diſtance from a fire, both will receive heat alike; and the ice will be melted into water at 32°, while the water in the other veſſel will have its temperature raiſed to 178°. Here it is obvious that the ſame heat which raiſed the water 146 degrees, was merely ſufficient to ſupply the increaſed capacity of the ice; for which reaſon this laſt had not its temperature raiſed at all. If the experiment be more accurately made, by mixing equal weights of water at 178°, and ice at 32°, the ſame conſequence will follow;

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* For which conſult Dr. Crawford's Treatiſe, already ſpoken of.

for the ice will be melted, and the common temperature will be 32°; becauſe the ice in melting receives no augmentation of temperature, but abſorbs the whole 146° of heat from the water, by virtue of its increaſed capacity when it becomes fluid.

Stationary temperature, or freezing point.

And ſo likewiſe, when water is frozen by the loſs of its heat, communicated to a cold atmoſphere, or other contiguous bodies, the proceſs of cooling goes on till ice begins to be formed: but, during the whole time of the converſion of the water into ice, the temperature remains ſtationary, becauſe the diminiſhed capacity of the ice cauſes it to give out heat, the continual evolution of which ſupplies the refrigerating bodies with as much as their energy of cooling might otherwiſe have taken to cauſe a diminution of the temperature. When the whole is frozen, this ſupply of extricated heat ceaſes; and therefore the cauſe that cooled the water at firſt, goes on in cooling the ice, until the common temperature is produced.

Natural zero of temperature.

In all experiments wherein the capacities of the ſame bodies are changed, and the difference between the quantities of heat in the ſame body in both ſtates, at one common temperature, is known in degrees of the thermometer, we may derive the advantage of finding the abſolute quantities of heat in degrees of the thermometer, or the number of degrees which any particular point or temperature is remote from the true zero, or point of abſolute privation of all heat. To illuſtrate this curious poſition, the experiments on ice and water, juſt related, may be made uſe of. The whole quantities of heat, in theſe two ſtates, are as 9 to 10. It is plain, therefore, that when water freezes

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it muſt give out one-tenth of its whole heat; and this tenth part, by the experiment, is found to anſwer to 146° of Fahrenheit's thermometer. Conſequently its whole heat is ten times 146°, or 1460° of Fahrenheit's thermometer, when its temperature is 32° above Fahrenheit's zero. Whence the natural zero * is at—1428°.

Capacity of ſteam.

No direct experiment has yet been made to ſhew the capacity of ſteam with relation to water. An indirect experiment of Dr. Crawford makes it as 15½ to 10 †. It is accordingly found that ſteam, in its condenſation into water, gives out as much heat as would raiſe an equal quantity of non-evaporable matter, of the ſame capacity as water, 914 degrees. This heat it muſt have taken up at its formation. Whenever water s heated, we may conſequently conſider the heat as diſpoſed of in two ways. One part raiſes the temperature of the fluid water, and the other part is employed in ſupplying the elaſtic vapour that flies off with the heat which its increaſed capacity requires at that emperature. The greater the quantity of ſteam is roduced, the larger will be the proportion of the heat mployed in this laſt way. Now, there is a difficulty ttends the formation of elaſtic vapour, in proportion as s eſcape is rendered more difficult. If the water be eated in a cloſe veſſel, no ſteam will be formed; if he ſteam eſcape by a ſmall hole, there will be leſs ormed than if the whole ſurface of the water were ncovered; and if the ſuperincumbent atmoſphere be emoved, as in the vacuum of an air-pump, the production will be greateſt of all. As the heat of the

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* Crawford, p. 458.

† Ibid. page 270.

water goes on increaſing, the production of ſteam will likewiſe increaſe, until the quantity is ſo great as its augmented capacity to carry off the whole heat that is communicated. At this period the increaſe of temperature will therefore ceaſe, and the temperature will become ſtationary. This point is called the boiling-water point. It varies, however, a little, as the preſſure of the atmoſphere varies, being loweſt when that is leaſt; becauſe the maximum of ſteam is produced at a lower temperature when the obſtacle to its eſcape is leſs. It has been ſtated, and with ſome probability, that there might be no interval of fluidity between th ſolid and vaporous forms, if it were not for the preſſur of the atmoſphere.

Boiling-water point of temperature.

Evaporation produces cold.

In this manner it is eaſy to account for the col produced by evaporation: for the volatile ſubſtance when it takes the vaporous form, abſorbs as much hea from the body from which it evaporated, as its increaſe capacity requires. Every one muſt be acquainted wit the cold produced by wetting the hand with water o with ſpirits of wine or brandy. The freezing of water, b means of the evaporation of ether, is a very remarkab inſtance of this. Water is included in a thin glaſs tub and the outſide of the tube is kept continually wett with ether, by means of a bottle with a capillary tube its neck, through which the ether is poured. The conſ quence of the ſpeedy evaporation of this very volati fluid is, that in a very ſhort time the included water ſuddenly converted into ice, even before a fire, or the midſt of ſummer.

Freezing by evaporation.

Freezing mixtures.

The effect of freezing mixtures is another evide conſequence of this doctrine. When as much co

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on ſalt is added to water as it can diſſolve, the brine
ntinues unfrozen till it is cooled as low as 6° below
, on Fahrenheit's ſcale. Suppoſe pounded ice, or
ow, to be mixed with ſalt at any temperature above
6°, their union will produce the brine here men-
ned; which, becauſe the heat is above its freezing
int, will become fluid, though the ice and ſalt were
id before. This fluidity will be attended with an
reaſe of capacity, and therefore the brine will be
uch colder than the ſnow and ſalt were. If the quan-
y of ſnow and ſalt be conſiderable, and there be no
dies at hand which can readily ſupply heat, the brine
ſt produced will cool the ſnow and ſalt in its vicinity;
d this, when lequefied, will cool the reſt of the ſnow
d ſalt ſtill more effectually. When the temperature
the whole is as low as —6°, or the freezing point of
e brine, the liquefaction and cooling will ſtop, or it
ll proceed more ſlowly or faſter, in proportion as the
uiſite heat is ſupplied. It may eaſily be imagined
it, if a mixture of this kind be placed in a veſſel, and
maller veſſel, containing water, be plunged in it,
cooling proceſs will freeze the water. It is like-
ſe evident that ſuch mixtures will deſcend to a fixed
nperature, which is that of their own freezing point*.
So likewiſe the freezing proceſſes by the ſolutions †
ſalts in water or acids, though they have not yet been
minutely examined, may be explained from the dif-
ence of capacity produced in the liquefaction of
id ſalts, or the water contained in them. One of

Fixed temperature of freezing mixtures.

Freezing proceſſes by diſſolving ſalts in water.

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* Crawford, p. 474.

† Walker, in Philoſ. Tranſ. Vol. LXXVII. and LXXVIII.

Mixture of ſalts for freezing water.

theſe may be here mentioned, not as the moſt powerful, but becauſe the materials are cheap, and well known. It conſiſts of equal parts of ſal-ammoniac and ſaltpetre, finely powdered. If four ounces of water be poured on three ounces of this mixture, the ſolution will ſink the thermometer 36 degrees; and as it is eaſy to have pump-water as cool as 50° in the midſt of ſummer, this addition will cool it to 14°, which i therefore ſufficient to freeze water in a phial plunged in it.

General view of the agency of heat.

Without entering more largely into examples of th conſequences of the change of capacity in bodies which are changed in their form, or ſtate of chemical combination, it may be obſerved, in general, that as th powers of gravity and projection, in continual oppoſition to each other, produce all the beautiful effects i the great ſyſtem of the univerſe to which they are eſſential; ſo, among the actions of the minute parts o bodies, the coheſive attraction, and the energy of he are in continual oppoſition to each other, and are concerned in every proceſs by which changes are produced in the peculiar properties of bodies: and fo whatever more immediate purpoſes it may be that th Supreme Intelligence has thus generally appointed the agency, we ſee that the changes of capacities ar greatly conducive to the preſervation of a more equ temperature than would otherwiſe be found in th diſtricts around us. The cold produced by evaporatio greatly mitigates, and conducts to other parts, t ſtrong heats of the torrid zone; and the heat develop on the freezing of water prevents the cold from falli ſo far below the freezing point as otherwiſe it mig

Advantages ariſing from the changes of capacities.

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ſo. If the capacities of water and ice were equal, the reezing of immenſe bodies of water would ſcarcely be rogreſſive, but would take place the inſtant the whole vas cooled to 32°; and ſo likewiſe the thawing of aſt tracts of ſnow and mountains of ice would be erformed in the ſhort time of the tranſmiſſion of the eat required to raiſe its temperature the minuteſt portion of a degree above the temperature of ſolidity. Whether the extreme inconveniences the hotter climates would undergo from increaſed heat, or the older from the intenſe freezing and ſudden thaws, be mong the principal events in the view of the Sovereign Diſpoſer of the univerſe, cannot, from our ignoance of final cauſes on ſo large a ſcale, be determined.

Queſtion, page 6.

Whether heat be matter or motion, is a queſtion vhich, as was before obſerved, is not well ſettled. It certain that the motion of friction, or percuſſion, ither produces or collects heat; and if the ſuppoſition f the mere vibration of parts could adequately account r the effects, it would doubtleſs be more ſimple than call in the aſſiſtance of a material ſubſtance endued ith peculiar properties. But, on the other hand, the pearances are ſolved with great eaſe and ſimplicity y the ſuppoſition of ſuch a ſubſtance. On this ſub-ct it may perhaps be ſufficient to obſerve, that the henomena of heat ſeem to ſtand ſingle, ſo as not aſily to admit of compariſon with any of the other ppearances in nature; and conſequently that all rea-ning by analogy promiſes very little elucidation of a ubject which can only be proſecuted by experimental ſearch.

The philoſophy of heat admits no analogy.

HEAT.

Diminution of capacity increaſes weight.

Attempts have been made to determine whether the weight of bodies is affected by the greater or leſs quantity of heat they may contain. The moſt accurate experiments ſhew that the ſame water is heavier, b a very minute quantity, when it is converted int ice*.

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* Dr. George Fordyce made the experiment by weighing th ſame quantity of water (about 1700 grains), when frozen an when unfrozen, at the temperature of 32°, in a room where th air was of the ſame temperature. The ice was near one-ſixteent of a grain heavier. Phil. Tranſ. Vol. LXXV. p. 362.—Sir Benjamin Thompſon obtained the ſame concluſion, by counterpoiſi water againſt ſpirit of wine, and expoſing the apparatus to a col atmoſphere which froze the former.

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CHAP. III.

THE CONSTRUCTION OF THE THERMOMETER.

THERMOMETER.

Conſtruction of the thermometer.

IN the preſent cultivated ſtate of philoſophical knowledge, it can hardly be ſuppoſed that the reader has not ſeen a thermometer. Minute deſcription is therefore unneceſſary. But as the accurate conſtruction and ſubſequent improvement of this inſtrument muſt greatly depend on the knowledge, which thoſe who uſe it may poſſeſs, of the method of making it; and as we have no perfect account of this, there can be no doubt but a ſhort relation of the whole proceſs, from experimental knowledge, will be acceptable.

To determine the cylindrical form of the bore.

The tubes may be had at the glaſs-houſe; and the firſt care of the artiſt muſt conſiſt in examining if their cavities be equal or cylindrical throughout. This is done by immerſing one end into mercury, and withdrawing it, after cloſing the other end with the finger. By this means a ſmall quantity of mercury will enter the tube, which will occupy a longer ſpace the deeper the tube is immerſed. Lay the tube horizontally upon a graduated rule, and obſerve the length of the mercurial column, in different parts of the tube to which it may be made to run, by inclining it more or leſs. If the length continues invariably the ſame, it is a proof that the tube is uniformly cylindrical; but, if otherwiſe, the diameter varies, and the tube cannot be uſed to make a good thermometer, unleſs the graduations in the different

ferent parts of the tube be lengthened or ſhortened, in proportion to the meaſures of the mercurial column.

Method of blowing thermometers.

Direct the flame of a large candle, a watch-maker's lamp, or, which is cleanlieſt and beſt of all, a lamp with ſpirits of wine, upon one end of the glaſs tube, by means of the blow-pipe. The extremity will ſoon become red hot, and in a ſtate of imperfect fuſion. Remove the tube from the flame, and blow into its other end, and the heated part will be inflated ſo as to form a bulb. This laſt inflation is the moſt difficult and laborious part of the buſineſs; but it may be performed with great eaſe and advantage, by previouſly faſtening the neck of one of the ſmall bottles of elaſtic gum, or India rubber, about the end of the tube; which, when the other end is ignited, may be preſſed by the hand, ſo as to blow the bulb very commodiouſly, and without the introduction of any moiſt air.'

Filling with mercury.

Immerſe the open end of the thermometer tube into ſome very clean dry mercury that has been boiled, and warm the bulb with a candle; part of the air will be immediately heard ruſhing through the mercury; withdraw the candle, and, as the bulb cools, the mercury will riſe in the tube. This will be facilitated by holding the tube as near an horizontal poſition as can be done, without raiſing its lower end above the ſurface of the mercury. In this way the bulb will be nearly half filled. Without altering the poſition of the apparatus, move the whole ſo that the bulb may be held over a candle. A ſmall candle newly ſnuffed is beſt, becauſe of the ſteadineſs of its flame; and it will be neceſſary to wrap a piece of paper round the tube, to

THERMOMETER.

ſend the finger and thumb from its heat. The mer- ry will ſoon boil, and moſt of the remaining air will heard eſcaping from the bulb. As ſoon as this cape has ceaſed, remove the bulb from the candle, id it will be ſuddenly filled with mercury from the ſſel.

Boiling the mercury in the tube.

Take the thermometer thus filled out of the mer- ıry, and wrap round its open end a piece of thin pa- r, in ſuch a manner as to leave a cavity beyond the ıbe, at leaſt ſufficient to hold as much mercury as ıe bulb contains; ſecure this by wrapping it tight ith packthread about the tube; then put a drop of ıercury into the paper cavity, and apply the bulb gain over the ſnuffed candle, holding the tube up- ight between the finger and thumb, or a pair of ſmall incers, at the part wrapped with paper and pack- hread: the mercury will ſoon boil, and about half ıe contents of the bulb will ruſh violently up the ıbe into the paper. Remove the bulb from the can- le, and the mercury will ſuddenly return: then boil again; and repeat the operation till the ſpeedy boil- ıg of the mercury, when placed over the candle, and ıe diminiſhed noiſe and agitation, ſhew that the whole ıas been well heated, and deprived of the air or moiſ- ure which might have adhered to it.

Caution.

The operation of boiling will fail, if the mercury, r the inſide of the bulb, be moiſt; for in this caſe he bulb is uſually burſt by the mercurial vapour; the xploſion however is not dangerous: it is very likely o happen with bulbs blown by the mouth, unleſs they e kept ſome weeks in a dry place, before they are lled. The ſame danger makes it prudent not to boil

the mercury ſtrongly the firſt or ſecond time
and it is likewiſe of importance to keep th
bulb clear of the flame, as the contact of this la
againſt the empty part of the bulb would melt it, a
a hole would be immediately made by the exclude
vapour.

Trial of the proportion between the bulb and the tube.

After the boiling is completed, plunge the bulb in
cold water, whoſe temperature is known. Meltin
ice or ſnow (or ſnow and water) always has the te
perature of 32° of Fahrenheit's ſcale. Then take o
the paper, and put the bulb into the hand, and afte
wards into the mouth; this heating will cauſe ſome
the mercury to drop out of the tube. Cool it aga
to 32°, by immerſing it in the cold water, and ma
where the mercury ſtands. The diſtance betwee
this ſtation and the top of the tube meaſures the inte
val between freezing and blood heat, or 32 and 9
which makes 63 degrees; and will conſequently ſhe
whether the degrees will be large or ſmall, and wh
extent the ſcale is capable of; that is to ſay, it w
ſhew whether the bulb is of the proper ſize. Th
laſt, ſuppoſing the judgment of the operator n
ſufficient to proportion the bulb nearly to the tub
and the intended ſcale, might however have been mo
conveniently aſcertained after the firſt filling, befo
the boiling had been undertaken.

Hermetical ſealing of the tube.

When the number of degrees to which the leng
of the tube will extend is thus known, the operat
muſt ſettle whereabouts he will have the freezi
point, which may be nearer or farther from the bul
accordingly as he intends the inſtrument to be uſe
more particularly to aſcertain great degrees of he

or of cold. At this ſtage of the buſineſs, likewiſe, he may heat the upper part of the tube with the blow-pipe, and draw it out to a fine capillary tube ready for ſealing. The bulb muſt then be heated in the candle, till a few particles of mercury have fallen off the top of the tube; and notice muſt then be taken how much nearer the freezing point is to the bulb than before, which may be done by immerſing it in the melting ſnow, as before. If it be not as low as deſired, the heating muſt be repeated, carefully obſerving not to throw out too much mercury at a time. When the due quantity of mercury is thus adjuſted, two candles muſt be prepared, the one to heat the bulb, and the other to cloſe the tube. The blow-pipe being in readineſs, the upper part of the tube near the flame of one candle, and the bulb near the flame of the other, the mercury will riſe, and at laſt begin to form a globule at the point of the capillary tube. At this inſtant the bulb muſt be withdrawn from the lower candle, at the ſame time that the flame of the upper is directed by the blow-pipe upon the point of the tube. This laſt will be immediately ignited, and will cloſe by the melting of its parts, before the mercury has perceptibly ſubſided. When the mercury has fallen, this cloſure may be rendered more ſecure from accidental breaking, by fuſing the whole point of the tube, till it becomes round.

Proof of internal vacuum.

If this buſineſs be properly done, the mercury in the inſtrument thus filled will run backwards and forwards in the tube, immediately upon inverting its ſituation.

In

THERMOMETER.

Adjuſtment of the fixed points.

In the original graduation of thermometers, two fixed points of temperature are neceſſary. Theſe are the freezing point of water, or temperature of ice or ſnow, at the inſtant of formation, or rather when it is juſt beginning to liquefy; and the boiling point of water, or temperature at which, under a known preſſure, it is plentifully converted into ſteam. For the ſettling the freezing point, nothing more is neceſſary than to immerſe the thermometer ſo deep in melting ſnow or ice, as that the mercury may be barely viſible above its ſurface, and carefully mark the place at which it ſtands.

Freezing.

The boiling point is not quite ſo eaſily aſcertained; crude, hard, or ſaline waters acquire a greater heat in boiling than ſuch as are purer; and the ſame water will acquire a greater heat under a greater preſſure. For this laſt reaſon, the boiling point ſhould be fixed according to the deciſion of the committee of the Royal Society; namely, when the barometer ſtands at 29.8 inches. The beſt method is to provide a veſſel ſomewhat longer than the thermometer, with a cover, and two holes in it; one about an inch in diameter, for the ſteam to eſcape; and the other ſmaller, for the thermometer tube to be faſtened in it. When this is uſed, the thermometer muſt be faſtened in the cover, ſo that the eſtimated place of the boiling point may be juſt above the hole. Water muſt be put in the veſſel, not ſufficient to touch the bulb of the thermometer, when the cover ſhall be put on. The veſſel muſt then be covered, a thin plate of metal laid on the ſteam hole, and the water made to boil by heat applied to the bottom only. The thermometer will be then ſurrounded with ſteam, which will raiſe its temperature

Boiling.

perature to the boiling point; and this point muſt be carefully marked on the tube. The following method may be more convenient to thoſe who are not provided with ſuch a veſſel:—Wrap ſeveral folds of linen rags or flannel round the tube, nearly as high as the ſuppoſed boiling point; hold the ball of the thermometer in the aſcending current of boiling rain-water, about two or three inches below the ſurface; pour boiling water on the rags three or four times, waiting a few ſeconds between each time; and wait ſome ſeconds after the laſt time of pouring on water, in order that the water may recover its full ſtrength of boiling, which is conſiderably checked by the pouring on the rags. The place where the mercury ſtands is the boiling-water point.

Adjuſtment for errors of the tube.

Notwithſtanding the accurate adjuſtment of the fixed points of a thermometer, yet if the tube be not truly cylindrical, or if the diviſions be not adjuſted to the inequalities of its diameter, the errors at the middle, between the two fixed points, may amount to more than a whole degree. A ſmall error in the ſtanding of thermometers may be occaſioned by the varying preſſure of the atmoſphere, which alters the capacity of the glaſs; but it never amounts to ſo much as the tenth part of a degree. Spherical bulbs are leaſt ſubject to this.

Standard thermometer.

Thermometers which, from the great length of their degrees, or for any other reaſon, are made to take in but a ſmall part of the interval between the two fixed points, are uſually graduated by compariſon with a ſtandard thermometer.

Caſes in which the mercury need not be boiled.

The very careful boiling of the mercury, as above deſcribed, is abſolutely neceſſary for ſuch thermometers as are to be ſealed when full: for if there were any air or moiſture left in the bulb, it would prevent the mercury in the tube from deſcending into the bulb, ſo that the tube would continue always full. Theſe thermometers are undoubtedly the beſt; but the vacuum above the mercury does not ſeem to be an indiſpenſable requiſite. If a clean dry tube be filled with pure boiled mercury, and a ſmall bulb be left at the top of the tube, to contain common air, in order that its expanſion or condenſation, produced by the change in the mercurial ſurface, may be inconſiderable; there will be few practical objections againſt ſuch a thermometer; more eſpecially if it be a ſecondary inſtrument, graduated by means of a ſtandard. There are ſome thermometers made with tubes ſo very ſmall, and bulbs ſo large in proportion to them, that they will not admit of boiling the mercury in them, but are filled with boiled mercury by means of a condenſer. Theſe are neceſſarily of the kind here mentioned.

Scales of thermometers.
Fahrenheit's.

The thermometers moſt in uſe at preſent are Fahrenheit's, Reaumur's, and Celſius's. In Fahrenheit's ſcale the number of degrees between the freezing and boiling water point is 180; the freezing point being at 32°, and the boiling point at 212°, both above 0°, or the part from which the degrees are reckoned both ways. In Reaumur's ſcale the number of degrees between theſe two points is 80, and the freezing point is called 0°, from which the degrees are reckoned both ways. In Celſius's thermometer, the interval

Reaumur's.

Celſius's.

Reduction of degrees of thermometers of various ſcales.

rval is divided into 100°, and the freezing point is
lled 0°, as in Reaumur's. To reduce theſe ſcales
each other, it muſt be obſerved, that one degree of
hrenheit's is equal to $\frac{4}{9}$ of a degree of Reaumur,
d to $\frac{5}{9}$ of a degree of Celſius. Therefore, if the
umber of degrees of Fahrenheit, reckoned above or
low the freezing point, be multiplied by 4, and di-
ded by 9, the quotient will be the correſponding
umber on Reaumur's ſcale. Or if the multiplier
, and the diviſor 9, be uſed, the quotient will give the
egrees of Celſius's ſcale. And, contrariwiſe, if any
umber of degrees, either of Reaumur or Celſius, be
ultiplied by 9, and divided by 4 if of Reaumur, or
y 5 if of Celſius, the quotient will give the degrees
f Fahrenheit, reckoned either above or below the
reezing point, as the caſe may be.

CHAP. IV.

ON COMBUSTION, AND THE APPLICATION OF HEAT TO CHEMICAL PURPOSES.

APPLICAT. OF HEAT.

Friction; hammering; flint and ſteel.

THE methods of producing an increaſe of temperature are various. The friction of two piece of wood, in a turner's lathe, produces heat and flame a nail may be made red-hot by hammering it: an when flint and ſteel are ſtruck together, ſmall particle of the ſteel are ſeparated, which are in a ſtrong ſtate o deflagration, and, upon examination with the microſcope, are found to have been fuſed into hollow greyiſ balls. The ſun's light, concentrated by a convex lens or concave mirror, is likewiſe found to produce th moſt aſtoniſhing effects, by raiſing the temperature o bodies. And, among chemical mixtures, there ar many by which ignition and flame are produced In theſe, and in all inſtances where the temperature i raiſed, a diminution of the capacities of the bodies appears to be the effective cauſe.

Solar focus.

Chemical mixtures.

Combuſtion.

Moſt operations that require an increaſe of temperature, are performed by the communication of hea from bodies in combuſtion. The general facts reſpecting this wonderful proceſs, are the following:— There are certain bodies which, when ignited o heated ſo as to become luminous, will ſoon ceaſe t be ſo, by the loſs of that heat which they communicate to the bodies around them: but there are other

whic

Combuſtion.

hich, if ignited in contact with the air of the atmo- here, will not loſe their ignition, but continue to give ut heat, till their volatile parts are diſſipated, and the roperties of the remainder entirely changed. Theſe ſt are called combuſtible bodies. It is found by ex- eriment that the capacities or quantities of heat, in ombuſtible bodies, are not conſiderable; that the uantity of heat in atmoſpheric air, in the elaſtic ſtate, exceedingly great; and that part of this air is ab- rbed by bodies in combuſtion. If, therefore, the mperature of a combuſtible body be by any means raiſed, as that the chemical proceſs, by which air ecomes condenſed and combined with it, may go on, he temperature of the air will be raiſed, as its capa- ity is diminiſhed, in paſſing from the elaſtic to the olid ſtate; and it will therefore give out its heat to the ombuſtible body, which, inſtead of becoming colder, uſt increaſe in temperature, in proportion to the uantity of air condenſed in the ſame time, excepting far as this effect is diminiſhed by the conducting ower of the ſurrounding bodies.

Proceſſes.

The proceſſes which are performed by the ſimple pplication of heat, are as follow:

Roaſting.

Roaſting.—This conſiſts in expoſing mineral bodies o the heat of an open fire, for the purpoſe of diſſipat- ng their volatile contents.

Calcination.

Calcination is performed by expoſing bodies, in an pen veſſel, to a ſtrong heat, till no farther change can e produced in them. The body which remains, and ithſtands the fire, is called a calx. Both theſe terms re more particularly applied to metals. Such bodies s are very little changed by heat, are called refractory.

APPLICAT. OF HEAT.

Fuſion.

Fuſion conſiſts in heating bodies, in proper veſſels, till they become fluid. It is chiefly uſed for the purpoſe of uniting ſmaller bodies into one large maſs, and caſting them into moulds of any deſired figure. The facility with which metals may be united in this way, after they have been divided, is probably the circumſtance that induced mankind to uſe them as the mediums of exchange, or ſigns of value of all other commodities.

Digeſtion.

Digeſtion conſiſts in keeping bodies for a conſiderable time immerſed in a fluid at a higher temperature than that of the atmoſphere, in order that combinations may take place that could not elſe have been effected.

Cementation.

Cementation is a proceſs wherein ſolid bodies, one or more of them being pulverized, are expoſed to heat in proper veſſels, with the intention that the more volatile parts of the one body may unite with the other, or with its fixed parts.

Evaporation.

Evaporation conſiſts in the diſſipating of fluids by heat.

Concentration.

Concentration conſiſts in increaſing the proportion of ſaline matter in any watery fluid, either by evaporating part of the water, or by cauſing it to freeze and taking away the ice.

Diſtillation.

When evaporation is performed in veſſels either perfectly or nearly cloſed, ſo that the volatile parts which are raiſed in one part of the apparatus, may be received and condenſed in the other part, the proceſs is called diſtillation.

Rectification.

Rectification is a ſubſequent diſtillation of the product which comes over.

Sublimation.

In the diſtillation of ſuch bodies as are ſolid in

th

e uſual temperature of the atmoſphere, the vapours e ſcarcely condenſed before they become ſolid. In is caſe the proceſs is called ſublimation; and the ndenſed vapours, which uſually have a powdery :m, are called flowers. Such are the flowers of imſtone, of benjamin, of zinc, &c. Solid products, tained in this way, are called ſublimates.

Flowers.

Sublimates.

Common fire.

Some of theſe operations may be performed by a mmon culinary fire; and indeed moſt of them may ıen the quantities of matter are ſmall, which is uſu-y the caſe in philoſophical experiments. In the arts, ıere every proceſs requires to be repeatedly carried in the large way, a variety of furnaces have been ıtrived, to ſuit the various intentions of the opera-·s. But experimental inquiries demand the occa-nal exertion of every branch of chemical operation; · which reaſon, the furnaces and apparatus ought to conſtructed on as general principles as poſſible.

Crucibles. See the plate.

The veſſels uſed in chemiſtry are—Fig. 1. Crucibles, pots, made either of earth, black lead, forged iron, platina. They are uſed for roaſting, calcination, l fuſion.

Cucurbits, or mattraſſes.

Fig. 2. Cucurbits, mattraſſes, or bodies, which are ſs, earthen, or metallic veſſels, uſually of the ſhape an egg, and open at top. They ſerve the purpoſes digeſtion, evaporation, &c.

Retorts.

Fig. 3. Retorts are globular veſſels of earthen ware, ſs, or metal, with a neck bended on one ſide. Some orts have another neck or opening at their upper ·t, through which they may be charged, and the :ning may be afterwards cloſed with a ſtopper. eſe are called tubulated retorts.

APPLICAT.
OF HEAT.

Receivers.

Fig. 4. Receivers are veſſels, uſually of glaſs, of
ſpherical form, with a ſtraight neck, into which the ne
of the retort is uſually inſerted. When any prop
ſubſtance is put into a retort, and heated, its volat
parts paſs over into the receiver, where they are co
denſed.

Alembic — of
glaſs;

Fig. 5. The alembic is uſed for diſtillation when t
products are too volatile to admit of the uſe of the la
mentioned apparatus. The alembic conſiſts of a body
to which is adapted a head B. The head is of a
nical figure, and has its external circumference
baſe depreſſed lower than its neck; ſo that the vapo
which riſe, and are condenſed againſt its ſides, r
down into the circular channel formed by its depre
part, from whence they are conveyed by the noſe
beak C, into the receiver D. This inſtrument is
ſimple than the retort, which certainly may be u
for the moſt volatile products, if care be taken to
ply a gentle heat on ſuch occaſions. But the alem
has its conveniencies. In particular, the reſidues
diſtillations may be eaſily cleared out of the body
and, in experiments of ſublimation, the head is
convenient to receive the dry products, while the m
volatile and elaſtic parts paſs over into the receiver.

—of metal.

Fig. 6, Is the drawing of an alembic comm
made in metal. The head is contained in a veſſe
cold water, to accelerate the condenſation; a me
which is not ſo rational as that of cooling the rece
becauſe the coldneſs of the head, in the former
cauſes much of the vapour to fall again into the b

Still, for ardent
ſpirit.

Fig. 7, Repreſents the large ſtills uſed in the d
lation of ardent ſpirits. Inſtead of uſing a refriger

receiver, the ſpirit is made to paſs through a ſpiral
c, called the worm, which is immerſed in a tub of
d water. During its paſſage it is condenſed, and
nes out at the lower extremity, E, of the pipe, in a
id form.

Furnaces.

The beſt conſtruction of a furnace has not been well
ertained from experience. There are facts which ſhew
t a fire made on a grate near the bottom of a chim-
, of equal width throughout, and open both above and
ow, will produce a more intenſe heat than any other
nace. What may be the limits for the height of
chimney, is not aſcertained from any preciſe trials;
t thirty times its diameter would not probably be too
h. It ſeems to be a diſadvantage to contract the
meter of a chimney, ſo as to make it ſmaller than
t of the fire-place, when no other air is to go up
chimney than what has paſſed through the fire;
d there is no proſpect of advantage to be derived
m widening it.

Melting furnace.

Fig. 8, Exhibits the common ſmall furnace for
lting. A is the aſh-hole, where the air enters. C is
fire-place, containing a covered crucible ſtanding
a ſupport of baked earth, which reſts on the grate.
is the paſſage into E the chimney. At D is a ſhallow
ucible called a cupel, placed in the current of the
me; and at F is an earthen or ſtone cover, to be occa-
nally taken off, for the purpoſe of ſupplying the fire
ith fuel.

Reverberatory furnace.

Fig. 9, Is the reverberatory furnace. A is the fire-
ace, B the dome and chimney, which is moveable.
ſerves to reflect the flames, and cauſes them to ſur-

APPLICAT. OF HEAT.

round the veſſel c, which is by that means mor ſtrongly heated than otherwiſe.

Fuel.

Charcoal is the material moſt commonly uſed i furnaces. It produces an intenſe heat, without ſmoke but it is conſumed very faſt. Coke, or charred pit coal, produces a very ſtrong and laſting heat. Neither of theſe produce a ſtrong heat at a diſtance from the fire. Where the action of flame is required, woo or coal muſt be burned. Several inconveniencies attend the uſe of coal, as its fuliginous fumes, and it aptitude to ſtop the paſſage of air, by becoming fuſe It is uſed however in the reverberatory furnaces glaſs-houſes; and is the beſt material where veſſels ar to be ſupplied with a great quantity of heat at no grea intenſity, ſuch as in diſtilleries, &c.

Chemical bath.

In many operations where a moderate and regul heat is required, it is advantageous to uſe a bath, or t coat the veſſel intended to be heated. A chemic bath is uſually made by putting a quantity of water, ſan or other fluid or pulverulent ſubſtance, into a metall veſſel or pot, and immerſing the diſtilling veſſel in i When the water or ſand is once heated, it prevents th ſudden changes in the intenſity of the fire from affec ing the veſſel that contains the matter under examin tion. Chemical baths are made with water, ſand iron filings, mercury, and with the fuſible compoſitio of eight parts biſmuth, five lead, and three tin, whic becomes fluid with a leſs heat than that of boili water.

Coating.

Coating is chiefly intended to prevent glaſs veſſe from cracking by the ſudden variations of heat; an ſerves likewiſe to render them capable of preſervi th their figure in higher degrees of heat than they could ſuſtain without it. The materials are clay and fine ſand, well worked together into a paſte, and with the addition of ſome hair, ſuch as the bricklayers uſe. This is laid upon the veſſel in ſucceſſive thin coatings.

Lutes.

The joints or cloſures of veſſels are made tight by compoſitions called lutes. The clay and ſand uſed for coating, make a very good lute. In the diſtillation of ſubſtances which are not corroſive, it is found convenient to cloſe the junctures with paper, or linen, paſted on. Wet ſtrips of bladder may alſo be uſed in theſe caſes. Slaked lime and the whites of eggs form a good lute, which ſpeedily dries and becomes firm; but the compoſition called fat lute is uſed when the vapours are of a corroſive and volatile nature. This is compoſed of clay, firſt made very dry and pulverized, and then beat together into a paſte with linſeed oil which has been boiled upon litharge, and is known in the ſhops by the name of drying oil. Fat lute does not harden, but requires to be ſecured on its place by ſtrips of linen dipped in the lute made of lime and whites of eggs.

Fat lute.

Lamp.

The flame of a lamp with many ſmall wicks may be uſed in diſtillations that require a low heat.

Facility of making experiments.

An ingenious ſtudent in chemiſtry, when he has familiarized himſelf with the firſt principles, will ſoon perceive that there are few philoſophical inquiries, if any, that require a large apparatus of furnace, or veſſels. A tobacco-pipe is a very uſeful crucible, in which a great number of operations may be performed in a common fire, eſpecially if urged with a pair of good double bellows. An earthen pot, or iron ladle, will contain a ſand-bath; and apothecaries phials, or Florence

D 4 flaſks,

flaſks, ſerve very well for mattraſſes. Chafing-diſhes, or ſmall iron ſtoves, may be applied to ſerve many uſeful purpoſes. And the blow-pipe and ſpirit-lamp, with a ſet of very ſmall retorts and receivers, may be adapted to the performance of almoſt every part of experimental chemiſtry.

Moveable furnaces.

The black-lead pots are very convenient for conſtructing a variety of moveable furnaces. They may be cut without difficulty by a ſaw whoſe teeth are ſet wide; and very eaſily admit of being ſcraped, drilled, or ground with ſand, to give them the requiſite figure. In Dr. Lewis's conſtruction, from whom the four following figures are taken*, the pots which are intended to be applied to each other, are ground flat upon a ſtone, with a little ſand; the holes are ſawed with the common compaſs-ſaw of the carpenters, and are made a little narrower externally than internally; by which means it is eaſy to fit them with ſtoppers made out of the broken pieces, that may be bought where the pots are ſold. Three or four hoops of copper-wire, about the thickneſs of a crow quill, and firſt ſoftened by heating it red-hot, are faſtened round the pots in the moſt convenient places, to render them more durable by keeping their parts together, after they may have been craked. A thin copper hoop ſerves to ſecure the place of junction of two pots.

Furnace for open fire.

Fig. 10, Repreſents a furnace for open fire formed by one pot. The lower ſquare aperture is the door of the aſh-pit, and the upper one the door of the fire-place which, in the intentions this furnace is deſigned for, i pt ſhut. The charcoal is put in at the top, and ſup- ied with air by one or more of the lower apertures ; id the intenſity of the fire may in ſome meaſure be gulated by more or leſs cloſing of the apertures. If iron pot, a ladle, or an old frying-pan, containing nd, be put over this fire on three iron ſupporters, ſo to leave room for the eſcape of the burned air from e fire, a bath will be formed, in which digeſtions, ſtillations, and other chemical operations, may be per- rmed. The round hole in the bottom ſerves to in- rt the nozzle of a pair of bellows, which, when the ther apertures are ſtopped, converts it into a blaſt urnace.

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* Lewis's Philoſophical Commerce of Arts.

Bath.

Moveable wind furnace.

Fig. 11, Is a wind furnace, formed by two pots ap- lied mouth to mouth. An iron chimney compoſed of ieces, by which its length may be regulated ſo as to ncreaſe the draft at pleaſure, is put on the top. The rucible containing the ſubject matters, is placed upon circular piece of brick laid upon the grate, which revents the cold air from immediately ſtriking the rucible, and endangering the breaking it. The char- oal is put through the fire-place door, or larger aper- ure of the dome, or upper pot, which ſhould always e cloſed immediately after each ſupply of fuel. The wo oppoſite holes in the upper part of the dome af- ord the conveniency of paſſing an iron rod through, or ſafely and commodiouſly lifting it when intenſely heated.

Reverberatory furnace.

Fig. 12, Is a furnace conſiſting of two pots, ſeparated by an iron hoop, in which an opening or door is cut. It ſerves for a reverberatory furnace for diſtilling with retorts of earthen ware or coated glaſs. The

bottom

APPLICAT. OF HEAT.

bottom of the diſtilling veſſel reſts on two bars lai acroſs within the lower pot. If the grate of this fu nace be occaſionally changed for a larger, which ma be placed near the edge of the lower pot, a muffle, o ſmall earthen oven, may be placed in the midſt o the fire, with its mouth oppoſite the hole in the iro hoop. In this may be performed all proceſſes that r quire the admiſſion of air, and frequent inſpection, ſuc as aſſays, enamelling, &c.

Moveable blaſt furnace.

Fig. 13, Is an improved blaſt furnace. The p which contains the fuel for this purpoſe, has a numb of holes bored at ſmall diſtances, in ſpiral lines, all ov it, from the bottom up to ſuch an height as it is de ſigned the fuel ſhall reach. The crucible is place upon a proper ſupport in the bottom; and the hol are made, not in a perpendicular direction to i but oblique, that the ſtreams of air forced in throug them may but juſt touch it: by this means the cruc ble is in no danger of being cracked by the blaſt, an the impelled heat plays in a kind of ſpiral upon its ſu face. The lower pot receives this perforated pot to ſuch depth that all its holes hang in the cavity; which cavit having no other outlet than the aperture for the bellow the air blown in through this aperture neceſſarily di tributes itſelf through the perforations of the inner po Both pots may be of the largeſt ſize, the external na row part of the inner falling into the wide mouth o the outer. It wants no addition to its height; bu on the contrary, will be more commodious in regard t the inſpection and taking out of the crucible, if all th part above where the fuel reaches be ſawed away. Th moſt convenient cover for it, is an iron plate with

roun

ound hole in the middle, and a handle projecting at ne ſide for lifting it. (Letter A.)

The force of the fire being thus in a great meaſure oncentrated upon the crucible in the middle of the uel, the crucible is heated expeditiouſly, and with a ittle quantity of fuel, to a very intenſe degree; while he exterior parts of the furnace are of no great heat, nd permit the operator to approach without incomnoding him.

Blow-pipe.

Every effect of the moſt violent heat of furnaces may e produced by the flame of a candle, or lamp, urged pon a ſmall particle of any ſubſtance by the blow-pipe. This inſtrument is ſold by the ironmongers; and onſiſts merely of a braſs pipe, about one eighth of an nch diameter at one end, and the other tapering to a much leſs ſize, with a very ſmall perforation for the wind to eſcape. The ſmaller end is bended on one ſide. For philoſophical, or other nice purpoſes, the blow-pipe is provided with a bowl, or enlargment, B, (fig. 14), in which the vapours of the breath are condenſed and detained; and alſo with three or four ſmall nozzles, with different apertures, to be ſlipped on the ſmaller extremity. Theſe are of uſe when larger or ſmaller flames are to be occaſionally uſed; becauſe a larger flame requires a larger aperture, in order that the air may effectually urge it upon the matter under examination.

Artifice of blowing through the pipe.

There is an artifice in the blowing through this pipe, which is more difficult to deſcribe than to acquire. The effect intended to be produced is a continual ſtream of air for many minutes, if neceſſary, without ceaſing. This is done by applying the tongue to the roof of the mouth,

mouth, ſo as to interrupt the communication between the mouth and the paſſage of the noſtrils: by which means the operator is at liberty to breathe through the noſtrils, at the ſame time that, by the muſcles of the lips, he forces a continual ſtream of air from the anterior part of the mouth through the blow-pipe. When the mouth begins to be empty, it is repleniſhed by the lungs in an inſtant; while the tongue is withdrawn from the roof of the mouth, and replaced again in the ſame manner as in pronouncing the monoſyllable tut. In this way the ſtream may be continued for a long time without any fatigue, if the flame be not urged too impetuouſly; and even in this caſe no other fatigue is felt than that of the muſcles of the lips.

Flame urged by the blow-pipe.

A wax-candle of a moderate ſize, but thicker wick than they are uſually made with, is the moſt convenient for occaſional experiments; but a tallow-candle will do very well. The candle ſhould be ſnuffed rather ſhort, and the wick turned on one ſide towards the object, ſo that a part of it ſhould lie horizontal. The ſtream of air muſt be blown along this horizontal part as near as may be without ſtriking the wick. If the flame be ragged and irregular, it is a proof that the hole is not round or ſmooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure, and duly proportioned, the flame conſiſts of a neat luminous blue cone, ſurrounded by another flame of a more faint and indiſtinct appearance. The ſtrongeſt heat is at the point of the inner flame.

The ſubject to be heated.

The body intended to be acted on by the blow-pipe, ought not to exceed the ſize of a pepper-corn. It may be

laid

aid upon a piece of cloſe-grained well-burned charcoal, unleſs it be of ſuch a nature as to ſink into the pores of hat ſubſtance, or to have its properties affected by its nflammable quality. Such bodies may be placed in a mall ſpoon made of pure gold, or ſilver, or platina.

Advantages of the blow-pipe:

Many great advantages may be derived from the uſe of this ſimple and valuable inſtrument. Its ſmallneſs, which renders it ſuitable to the pocket, is no inconſiderable recommendation. The moſt expenſive materials, and the minuteſt ſpecimens of bodies, may be uſed in theſe experiments; and the whole proceſs, inſtead of being carried on in an opake veſſel, is under the eye of the obſerver from beginning to end. It is true that very little can be determined in this way concerning the quantities of products; but in moſt caſes a knowledge of the contents of any ſubſtance is a great acquiſition, which is thus obtained in a very ſhort time, and will at all events ſerve to ſhew the beſt and leaſt expenſive way of conducting proceſſes with the ſame matters in the larger way.

—its uſe rendered eaſy by bellows.

The blow-pipe * has deſervedly of late years been conſidered as an eſſential inſtrument in a chemical laboratory; and ſeveral attempts have been made to facilitate its uſe by the addition of bellows, or ſome other equivalent inſtrument. Theſe are doubtleſs very convenient, though they render it leſs portable for mineralogical reſearches. It will not here be neceſſary to enter into any deſcription of a pair of double bellows fixed under a table, and communicating with a blow-pipe

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* See Magellan's edition of Cronſtedt's Mineralogy, or Bergmann's Chemical Eſſays.

which

which paſſes through the table. Smaller bellows, of a portable ſize for the pocket, have been made for the ſame purpoſe. The ingenious chemiſt will find no great difficulty in adapting a bladder to the blow-pipe, which, under the preſſure of a board, may produce a conſtant ſtream of air; and may be repleniſhed, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furniſhed with a valve opening inwards.

Blow-pipe with vital air.

The chief advantage theſe contrivances have over the common blow-pipe is, that they may be filled with vital or dephlogiſticated air, which increaſes the activity of combuſtion to an aſtoniſhing degree.

CHAP. V.

CERNING THE METHODS OF MAKING EXPERIMENTS ON BODIES IN THE FLUID AND IN THE AERIFORM STATE.

PROCESSES WITHOUT HEAT.

ROM the preceding chapter, the methods of con-
ducting proceſſes, in which conſiderable heat is
uired, may be eaſily underſtood. Little need be ſaid
ncerning the manner of making experiments with
id bodies in the common temperature of the atmo-
ere. Baſons, cups, phials, mattraſſes, and other ſimilar
ſels, form the whole apparatus required for the pur-
ſe of containing the matters intended to be put toge-
er; and no other precaution or inſtruction is required,
n to uſe a veſſel of ſuch materials as ſhall not be cor-
led or acted upon by its contents, and of ſufficient
acity to admit of any ſudden expanſion, or frothing
the fluid, if expected. This veſſel muſt be placed
a current of air, if noxious fumes ariſe, in order
t theſe may be blown from the operator.

Apparatus for denſe fluids.

— for elaſtic fluids.

The method of making experiments with perma-
ntly elaſtic fluids or air, though ſimple, is not ſo
vious. We live immerſed in an atmoſphere not
eatly differing in denſity from theſe fluids; which are
t, for that reaſon, ſufficiently ponderous to be detained
open veſſels by their weight. Their remarkable le-
ty, however, affords a method of confining them, by
eans of other denſer fluids. Dr. Prieſtley, whoſe la-
urs have ſo far exceeded thoſe of his predeceſſors and
temporaries, both in extent and importance, that he

PROCESSES WITHOUT HEAT.

Apparatus for experiments with elaſtic fluids.

may with juſtice be ſtyled the father of this importan branch of natural philoſophy, uſes the following apparatus.

Fig. 15. A repreſents a wooden veſſel, or tub; K, K, K, is a ſhelf fixed in the tub. When this apparatus i uſed, the tub is to be filled with water to ſuch a height, as to riſe about one inch above the uppe ſurface of the ſhelf. B, G, F, are glaſs jars inverte with their mouths downwards, which reſt upon th ſhelf. If theſe, or any other veſſels open only at on end, be plunged under the water, and inverted afte they are filled, they will remain full, notwithſtandin their being raiſed out of the water, provided their mouth be kept immerſed; for in this caſe the water is ſuſtained by the preſſure of the atmoſphere in the ſam manner as the mercury in the barometer. It ma without difficulty be imagined, that if common air, o any other fluid reſembling common air in lightne and elaſticity, be ſuffered to enter theſe veſſels, it wi riſe to the upper part, and the ſurface of the wat will ſubſide. If a bottle, a cup, or any other veſſ in that ſtate which is uſually called empty, thoug really full of air, be plunged into the water with i mouth downwards, ſcarcely any water will enter, b cauſe its entrance is oppoſed by the elaſticity of the i cluded air; but if the veſſel be turned up, it immed ately fills, and the air riſes in one or more bubbles the ſurface. Suppoſe this operation to be perform under one of the jars which are filled with water: t air will aſcend as before; but, inſtead of eſcaping, will be detained in the upper part of the jar. In t manner, therefore, we ſee that air may be emptied o of one veſſel into another, by an inverted pouring,

whi

Apparatus for experiments with elaſtic fluids.

ich the air is made to aſcend from the lower to the per veſſel, in which the experiments are performed, the action of the weightier fluid, exactly ſimilar the common pouring of denſer fluids, detained he bottoms of open veſſels, by the ſimple action of vity. When the receiving veſſel has a narrow k, the air may be poured through a glaſs funnel, H.

Body and tube.

(fig. 15) is a glaſs body or bottle, whoſe bottom lown very thin, that it may ſupport the heat of a dle, ſuddenly applied, without cracking. In its neck itted, by grinding, a tube D, curved nearly in the m of the letter S. This kind of veſſel is very uſeful in ious chemical operations, for which it will be conient to have them of ſeveral ſizes. In the figure, body C is repreſented as containing a fluid, in the of combining with a ſubſtance that gives out air, ich paſſes through the tube into the jar B, under oſe mouth the other extremity of the tube is placed. E is a ſmall retort of glaſs or earthen ware, whoſe k being plunged in the water, beneath the jar F, is poſed to emit the elaſtic fluid, extricated from the itents of the retort, which is received in the jar.

Stand or ſupport of wire.

When any thing, as a gallipot, is to be ſupported at onſiderable height within a jar, it is convenient to e ſuch wire ſtands as are repreſented fig. 16. Theſe wer better than any other, becauſe they take up t little room, and are eaſily bended to any figure or ight.

Gun-barrel.

In order to expel air from ſolid ſubſtances by means heat, a gun-barrel, with the touch-hole ſcrewed up d rivetted, may be uſed inſtead of an iron retort.

APPARATUS FOR ELASTIC FLUIDS.

The ſubject may be put in the chamber of the barrel, and the reſt of the bore may be filled with dry ſand, that has been well burned, to expel whatever air it might have contained. The ſtem of a tobacco-pipe or a ſmall glaſs tube, being luted in the orifice of th barrel, the other extremity muſt be put into the fire that the heat may expel the air from its contents. Thi air will of courſe paſs through the tube, and may b received under an inverted veſſel, in the uſual manne

Phials with quickſilver.

But the moſt accurate method of procuring air fro ſeveral ſubſtances, by means of heat, is, to put them, they will bear it, into phials full of quickſilver, with th mouths inverted in the ſame, and then throw th focus of a burning lens or mirror upon them. For th purpoſe their bottoms ſhould be round, and very thi that they may not be liable to fly with the ſudden ap plication of heat. The body c anſwers this purpo very well.

Burning lens, or mirror.

Apparatus with mercury.

Many kinds of air combine with water, and ther fore require to be treated in an apparatus in whic quickſilver is made uſe of. This fluid being ve ponderous, and of conſiderable price, it is an obje of convenience as well as œconomy, that the troug and veſſels ſhould be ſmaller than when water uſed.

Combuſtion of air.

When trial is to be made of any kind of air, wh ther it be fit for maintaining combuſtion, the air m be put in a long narrow glaſs veſſel, whoſe mouth b ing carefully covered, may be turned upward. A of wax candle being then faſtened to the end of a wi which is bended ſo that the flame of the candle may

upp

APPARATUS FOR ELASTIC FLUIDS.

ermoſt, is to be let down into the veſſel, which ſt be kept covered till the inſtant of plunging the ted candle in the air.

Meaſuring tubes.

Where the change of dimenſions, which follows m the mixture of ſeveral kinds of air, is to be aſcer- ıed, a graduated narrow cylindrical veſſel may be de uſe of. The graduations may be made by pour- in ſucceſſive equal meaſures of water into this veſ- and marking its ſurface at each addition. The aſure may be afterwards uſed for the different kinds air; and the change of dimenſions will be ſhewn by riſe or fall of the mercury, or water, in the graduated ſel. The purity of common air being determinable the diminution produced by the addition of nitrous , theſe tubes have been called eudiometer tubes.

Eudiometers.

ere are inſtruments called eudiometers, which con- of an aſſemblage of parts adapted to the due mix- e of theſe airs, and the accurate meaſurement of change of bulk they undergo.

Management of powders.

There are ſome ſubſtances, more eſpecially powders, ich cannot conveniently be put in a phial, or paſſed ough a fluid. When air is to be extricated from, added to, theſe, there is no better method than to ce them on a ſtand under the receiver of the air- np, and exhauſt the common air, inſtead of ex- ding it by water or mercury. This proceſs re- res a good air-pump and careful management, erwiſe the common air will not be well excluded.

Electric ſpark.

It is frequently an intereſting object to paſs the elec- ſpark through different kinds of air, either alone mixed together. In this caſe a metallic wire may faſtened in the upper end of a tube, and the ſparks,

or

Electricity applied.

or ſhock, may be paſſed through this wire to the mercury or water uſed to confine the air. If there be reaſon to apprehend that an expanſion in the air ma remove the mercury or water beyond the ſtrikin diſtance, another wire may be thruſt up to receive th electricity, or two wires may be cemented into oppoſite holes in the ſides of an hermetically ſealed tube

Holes drilled in glaſs.

Holes may be made in glaſs for this and other chemical uſes, by a drill of copper, or ſoft iron, with emer and water; and, where this inſtrument is wanting, ſmall round file with water will cut a notch in ſma veſſels, ſuch as phials or tubes, though with ſom danger of breaking them. In ſome electrical exper ments of the kind here mentioned, there is reaſon expect a fallacious reſult from the wires being burne by the exploſion, or ſpark. For this reaſon the ele tricity may be made to paſs through the legs of a ſ phon, containing the air which is under conſiderati in the upper part of its curvature. One of the veſſ in which the legs of the ſyphon reſt, muſt therefore inſulated; and if any watery fluid be uſed to confi the air, it is generally ſuppoſed that no combuſti takes place.

Impregnation of water;

The proceſs of impregnating water with any aer fluid it will combine with, does not require any par cular apparatus, but may be performed with ſuch ute ſils as are every where to be met with. The m uſual operation of this kind is that of impregnat

—with fixed air.

water with fixed air; which may be done in the ſ lowing manner. The quart bottle C, fig. 17, is fil with water, and inverted into the baſon F, which li wiſe contains a little water. The inverſion may

ca

APPARATUS FOR ELASTIC FLUIDS.

ſily managed, without any of the contents of the bot- eſcaping, if its orifice be covered with a card, to withdrawn after the immerſion. A is a half-pint ial, into which broken pieces of marble or chalk are t; and upon them is poured as much water, ren- red very acid by a mixture of oil of vitriol, as may l the bottle two-thirds. B is a bladder, whoſe neck tied faſt round a perforated cork of a tapering figure. fter the effervefcence of the chalk and the acid has gun, the cork is to be thruſt into the neck of the iial A, the bladder being previouſly emptied by preſ- re. Fixed air will eſcape from the chalk, and inflate ie bladder. When this laſt is full, it muſt be diſ- ngaged from the bottle, and the bended tube E muſt thruſt into the orifice of its cork. The aperture of ie tube being then placed beneath the mouth of the ottle C, it is eaſy to diſcharge the aerial contents of ie bladder by preſſure into this laſt. Agitation of ie bottle C, without withdrawing its neck out of the ater, increaſes the contact of the air and water, by ividing them into ſmall parts, and by that means auſes the abſorption to take place in a few ſeconds. wo or three repetitions of this proceſs impregnates he water ſo fully, that it will abſorb no more in this vay. The Pyrmont water is of this kind.

The uſe of the bladder, in this operation, is only o prevent any of the fluid contents of the bottle A from aſſing into the bottle C, which would happen in the iolent ſtate of ebullition, if the tube E were to paſs irectly from the bottle A to C. The manipulation is impler if the bladder have two holes at its oppoſite

APPARATUS FOR ELASTIC FLUIDS.

ends, the one containing a cork, conſtantly kept in the neck of the bottle A, and the other faſtened round the tube E, which then remains conſtantly beneath the mouth of C; and the air is preſſed up as occaſion may demand. See fig. 18.

Dr. Nooth's apparatus.

When habitual uſe is made of water impregnated with fixed air, the apparatus of Dr. Nooth is very effectual and convenient. It conſiſts of three glaſs veſſels (fig. 19). The lower veſſel C contains the effervеſcent materials: it has a ſmall orifice at D, ſtopped with a ground ſtopper, at which an additional ſupply of either acid, or water, or chalk, may be occaſionally introduced. The middle veſſel B is open both above and below. Its inferior neck is fitted by grinding into the neck H of the lower veſſel. In the former is a glaſs valve, formed by two pieces of tube, and a lens, which is moveable, between them, as repreſented in fig. 20. This valve opens upwards, and ſuffers the air to paſs; but the water cannot return through the tubes, partly becauſe the orifice is capillary, and partly becauſe the flat lens covers the hole. The middle veſſel is furniſhed with a cock E, to draw off its contents. The upper veſſel A is fitted, by grinding, into the upper neck of the middle veſſel. Its inferior part conſiſts of a tube, that paſſes almoſt as low as the centre of the middle veſſel. Its upper orifice is cloſed by a ground-ſtopper F. When this apparatus is to be uſed, the effervеſcent materials are put into the lower veſſel; the middle veſſel is filled with pure water, and put in its place; and the upper veſſel is nearly ſtopped, and likewiſe put in its place. The conſequence is,

tha

APPARATUS FOR ELASTIC FLUIDS.

Dr. Nooth's apparatus:

t the fixed air, paſſing through the valve at H, ends into the upper part of the middle veſſel B, ere, by its elaſticity, it re-acts on the water, and ces part up the tube into the veſſel A; part of the nmon air, in this laſt, being compreſſed, and the t eſcaping by the ſtopper, which is made of a conical figure, that it may be eaſily raiſed. As more fixed is extricated, more water riſes, till at length the iter in the middle veſſel falls below the lower orifice the tube. Fixed air then paſſes through the tube to the upper veſſel, and expels more of the common r by raiſing the ſtopper. In this ſituation the water both veſſels, being in contact with a body of fixed r, becomes ſtrongly impregnated with that fluid, afr a certain time. This effect may be haſtened by king off the middle and upper veſſels together, and gitating them.

—its valve defective.

The valve is the moſt defective part of this appatus: for the capillary tube does not admit the air rough, unleſs there be a conſiderable quantity conenſed in the lower veſſel: and the condenſation has, ſome inſtances, burſt the veſſel.

Improvements in diſtillation.

Modern diſcoveries, reſpecting bodies in the aeriform ate, have produced ſeveral capital improvements in he veſſels uſed for diſtillation. It was common with he earlier chemiſts to make a ſmall hole in the upper art of their retorts, that the elaſtic vapours might ſcape, which would otherwiſe have burſt the veſſels. By this means they loſt a very conſiderable part of heir products. Fig. 21, is an apparatus of veſſels*,

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* Prieſtley, III.

Combination of receivers.

in which all the products may be examined. A is a mattraſs, which communicates with the receiver B, by a tube that reaches very near the bottom of the latter. The upper part of this receiver communicates in the ſame manner with the ſecond receiver C, by a tube reaching nearly to the bottom of C. In like manner C communicates with D, and from D proceeds a recurved tube, which may be inſerted beneath an inverted veſſel of water, or mercury. It is evident, in this apparatus, that whatever volatile matter eſcapes from the veſſel A, by heat or otherwiſe, will either be condenſed in B, C, or D; and that the aerial products will paſs through the whole ſet, and through the recurved tube, into the inverted veſſel. Theſe receivers may be more or leſs numerous, according to circumſtances; and the volatile products may be condenſed in, or made to paſs through, water, oil, or any other fluids placed in either of the receivers. The tubes may be either fitted in with cork and cement; or, which is better, but more expenſive, by grinding. Small veſſels of this kind form a convenient interruption in the recurved tube, paſſing from a bottle containing matters that give out air, as they are preferable in cloſeneſs and neatneſs to a bladder.

Improved receiver.

Fig. 22, Exhibits an improvement in the receiver in diſtillation *. A is the retort. B an intermediate veſſel, called an adopter, which is only occaſionally uſed. C the receiver, having two necks; one at D, inſerted into a bottle which receives the products which are

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* By Mr. Woulfe. Prieſtley, III.

uſually

VESSELS FOR DISTILLING.

ſually condenſed in the receiver; and the other, at E,
ranſmits the more volatile or aeriform products into a
aſon G, containing water; beneath the ſurface of
vhich the extremity of the neck E is plunged. It is
bvious that this apparatus is more particularly uſeful
vhen the products are ſuch as combine with the fluids
n G, and would otherwiſe eſcape; and it is hardly ne-
eſſary to obſerve, that a bottle, or other convenient
eſſel, may be ſubſtituted inſtead of the baſon G.

Remedy againſt abſorption.

It often happens in chemical proceſſes, from the ir-
egularity of the heat, or from other circumſtances,
hat the condenſation is more rapid, in proportion to
he ſupply of vapour, at ſome periods of the ſame ope-
ation than at others. Whenever this takes place, the
laſticity of the vapours will not be equal to the exter-
al preſſure of the air; and if any orifice of the veſ-
els, which are in other reſpects cloſed, be plunged in
ater, or any other fluid, this laſt will be preſſed into
e veſſels. The remedy for this inconvenience is, to
lunge the neck of the veſſel to no greater depth in
e water, than that the fall of the water, in the re-
eiving veſſel, may leave the orifice open for the ad-
iſſion of air, before the water has riſen high enough
bove the orifice to reach the contents of the veſſels.
his effect is increaſed by making the neck large, in
roportion to the diameter of the veſſel which contains
he water. Thus, if the neck E be made large, and
he water from the baſon G ſhould, by a rapid conden-
ation in C, be forced up the neck, the ſurface of the
vater in G will fall ſo much as to leave the lower ori-
ice of E uncovered, before any conſiderable riſe can

take place; but if F were narrower, its whole capacity would be filled, and the water would run over into c before the fall in G would be ſufficient to uncover the orifice of F, and reſtore the equilibrium, by admitting common air. This obſervation applies to all chemical veſſels, and is in no caſe more eſſential than when the neck of a ſimple retort is plunged in water contained in a receiver.

Remedy againſt abſorption:

The above contrivance, which is Mr. Babington's, cannot very conveniently be applied to the apparatus Fig. 21, in which nevertheleſs the condenſation of elaſtic matter in the retort might occaſion a diſagreeable return of the fluids from the reſpective bottles in ſucceſſion. Chaptal remedies this by a very ſimple expedient. He has the tube of communication between A and B rather too ſhort to reach the liquid in B; and through the bottom or upper part of this inverted receiver B he paſſes a ſmall tube open at both ends, and plunged into the liquid. This communication with the external ai has no perceptible effect, as far as relates to any eſcap of the vapours; though it effectually remedies the conſequences of abſorption.

—of Chaptal.

CHA

CHAP. VI.

CONCERNING THE BALANCE AND WEIGHTS, WITH A COMPARATIVE TABLE OF THE VARIOUS WEIGHTS MADE USE OF IN EUROPE.

THE BALANCE.

THE beginning and end of every exact chemical proceſs conſiſt in weighing. With imperfect inſtruments this operation will be tedious and inaccurate: but, with a good balance, the reſults will be ſatisfactory; and much time, which is ſo precious in experimental reſearches, will be ſaved. I have not, therefore, thought it improper to devote a whole chapter to this general and important ſubject; by the help of which, if attentively conſidered, the chemical ſtudent may learn to diſtinguiſh a good inſtrument, or correct the errors of a bad one.

Balance deſcribed.

The balance is a lever, whoſe axis of motion is formed with an edge like that of a knife; and the two diſhes at its extremities are hung upon edges of the ſame kind. Theſe edges are firſt made ſharp, and then rounded with a fine hone, or a piece of buff leather. The excellence of the inſtrument depends, in a great meaſure, on the regular form of this rounded part. When the lever is conſidered as a mere line, the two outer edges are called points of ſuſpenſion, and the inner the fulcrum. The points of ſuſpenſion are ſuppoſed to be at equal diſtances from the fulcrum, and to be preſſed with equal weights when loaded.

Points of ſuſpenſion.

Fulcrum.

1. If

THE BALANCE.

Propoſitions.

1. If the fulcrum be placed in the center of gravity of the beam, and the three edges lie all in the ſame right line, the balance will have no tendency to one poſition more than another; but will reſt in any poſition it may be placed in, whether the ſcales be on or off, empty or loaded.

2. If the center of gravity of the beam, when level, be immediately above the fulcrum, it will overſet by the ſmalleſt action; that is, the end which is loweſt will deſcend: and it will do this with more ſwiftneſs the higher the center of gravity, and the leſs the points of ſuſpenſion are loaded.

3. But if the center of gravity of the beam be immediately below the fulcrum, the beam will not reſt in any poſition but when level; and, if diſturbed from that poſition, and then left at liberty, it will vibrate, and at laſt come to reſt on the level. Its vibrations will be quicker, and its horizontal tendency ſtronger, the lower the center of gravity, and the leſs the weight upon the points of ſuſpenſion.

4. If the fulcrum be below the line joining the points of ſupenſion, and theſe be loaded, the beam will overſet, unleſs prevented by the weight of the beam tending to produce an horizontal poſition; as in § 3. In this laſt caſe, ſmall weights will equilibrate, as in § 3; a certain exact weight will reſt in any poſition of the beam, as in § 1; and all greater weights will cauſe the beam to overſet, as in § 2. Money ſcales are often made this way, and will overſet with any conſiderable load.

Money ſcales.

5. If the fulcrum be above the line joining the points of ſuſpenſion, the beam will come to the horizontal

THE BALANCE.

Propoſitions.

zontal poſition, unleſs prevented by its own weight, as n § 2. If the center of gravity of the beam be nearly n the fulcrum, all the vibrations of the loaded beam will be made in times nearly equal, unleſs the weights e very ſmall, when they will be ſlower. The vibrations of balances are quicker, and the horizontal tendency ſtronger, the higher the fulcrum.

6. If the arms of a balance be unequal, the weights n equipoiſe will be unequal in the ſame proportion. It is a ſevere check upon a workman to keep the arms equal, while he is making the other adjuſtments in a ſtrong and inflexible beam.

Weighing with a balance which is not equibrachial.

7. The equality of the arms of a balance is of uſe, in ſcientific purſuits, chiefly in the making of weights by biſection. A balance with unequal arms will weigh as accurately as another of the ſame workmanſhip with equal arms, provided the ſtandard weight itſelf be firſt counterpoiſed, then taken out of the ſcale, and the thing to be weighed be put into the ſcale, and adjuſted againſt the counterpoiſe. Or, when proportional quantities only are conſidered, as in chemical and other philoſophical experiments, the bodies and products under examination may be weighed againſt the weights, taking care always to put the weights in the ſame ſcale. For then, though the bodies may not be really equal to the weights, yet their proportions amongſt each other will be the ſame as if they had been accurately ſo.

8. But though the equality of the arms may be well diſpenſed with, yet it is indiſpenſably neceſſary that their relative lengths, whatever they may be, ſhould continue invariable. For this purpoſe, it is neceſſary either

either that the three edges be all truly parallel, or that the points of ſuſpenſion and ſupport ſhould be always in the ſame part of the edge. This laſt requiſite is the moſt eaſily obtained.

Conſtruction. The balances made in London are uſually conſtructed in ſuch a manner, that the bearing parts form notches in the other parts of the edges; ſo that the ſcales being ſet to vibrate, all the parts naturally fall into the ſame bearing. The balances made in the country have the fulcrum edge ſtraight, and confined to one conſtant bearing by two ſide plates. But the points of ſuſpenſion are referred to notches in the edges, like the London balances. The balances here mentioned, which come from the country, are incloſed in a ſmall iron japanned box; and are to be met with at the Birmingham and Sheffield warehouſes, though leſs frequently than ſome years ago; becauſe a pocket contrivance for weighing guineas and half guineas has got poſſeſſion of the market. They are, in general, well made and adjuſted, turn with the twentieth of a grain when empty, and will ſenſibly ſhew the tenth of a grain, with an ounce in each ſcale. Their price is from five ſhillings to half-a-guinea; but thoſe which are under ſeven ſhillings have not their edges hardened, and conſequently are not durable. This may be aſcertained by the purchaſer, by paſſing the point of a penknife acroſs the ſmall piece which goes through one of the end boxes; if it makes any mark or impreſſion, the part is ſoft.

The turn. 9. If a beam be adjuſted ſo as to have no tendency to any one poſition, as in § 1, and the ſcales be equally loaded; then, if a ſmall weight be added in one of the

ſcales,

THE BALANCE.

Propoſitions.

ſcales, that balance will turn, and the points of ſuſpenſion will move with an accelerated motion, ſimilar to that of falling bodies; but as much ſlower in proportion, very nearly, as the added weight is leſs than the whole weight borne by the fulcrum.

10. The ſtronger the tendency to an horizontal poſition in any balance, or the quicker its vibrations, § 3, 5, the greater additional weight will be required to cauſe it to turn or incline to any given angle. No balance therefore can turn ſo quick as the motion deduced in § 9. Such a balance as is there deſcribed, if it were to turn with the ten thouſandth part of the weight, would move at quickeſt ten thouſand times ſlower than a falling body; that is, the diſh containing the weight, inſtead of falling through ſixteen feet in a ſecond of time, would fall through only two hundredth parts of an inch, and it would require four ſeconds to move through one third part of an inch: conſequently, all accurate weighing muſt be ſlow. If the indexes of two balances be of equal lengths, that index which is connected with the ſhorter balance will move proportionally quicker than the other. Long beams are the moſt in requeſt, becauſe they are thought to have leſs friction. This is doubtful: but the quicker angular motion, greater ſtrength, and leſs weight, of a ſhort balance, are certain advantages.

Accurate weighing is ſlow.

Long beams.

11. Very delicate balances are not only uſeful in nice experiments, but are likewiſe much more expeditious than others in common weighing. If a pair of ſcales, with a certain load, be barely ſenſible to the one-tenth of a grain, it will require a conſiderable time to aſcertain the weight to that degree of accuracy, becauſe

THE BALANCE.
Propoſitions.

becauſe the turn muſt be obſerved ſeveral times over, and is very ſmall. But if no greater accuracy were required, and ſcales were uſed which would turn with the hundredth of a grain, a tenth of a grain more or leſs would make ſo great a difference in the turn, that it would be ſeen immediately.

12. If a balance be found to turn with a certain addition, and is not moved by any ſmaller weight, a greater ſenſibility may be given to that balance, by producing a tremulous motion in its parts. Thus, if the edge of a blunt ſaw, a file, or other ſimilar inſtrument, be drawn along any part of the caſe or ſupport of a balance, it will produce a jarring, which will diminiſh the friction on the moving parts ſo much that the turn will be evident with one third or one fourth of the addition that would elſe have been required. In this way a beam which would barely turn by the addition of the tenth of a grain, will turn with the thirtieth or fortieth of a grain.

13. A balance whoſe horizontal tendency depend only on its own weight, as in § 3, will turn with th ſame addition, whatever may be the load: except ſ far as a greater load will produce a greater friction.

14. But a balance whoſe horizontal tendency depends only on the elevation of the fulcrum, as i § 5, will be leſs ſenſible the greater the load; and th addition requiſite to produce an equal turn will be i proportion to the load itſelf.

15. In order to regulate the horizontal tendency i ſome beams, the fulcrum is placed below the points ſuſpenſion, as in § 4, and a ſliding weight is put upo the cock or index; by means of which the centre

gravi

THE BALANCE.

avity may be raiſed or depreſſed. This is an uſeful
ntrivance.

Sets of weights.

Common pile.

Biſection.

Wire rings.

16. Weights are made by a ſubdiviſion of a ſtand-
l weight. If the weight be continually halved, it
ll produce the common pile, which is the ſmalleſt poſ-
le number for weighing between its extremes, without
ıcing any weight in the ſcale with the body under
amination. Granulated lead is a very convenient
ſtance to be uſed in this operation of halving,
ich however is very tedious. The readieſt way to
divide ſmall weights, conſiſts in weighing a certain
antity of ſmall wire, and afterwards cutting it into
h parts, by meaſure, as are deſired. Or the wire
y be wrapped cloſe round two pins, and then cut
ınder with a knife. By this means it will be di-
led into a great number of equal lengths, or ſmall
gs. The wire ought to be ſo thin, as that one of theſe
gs may barely produce a ſenſible effect on the
m. If any quantity (as, for example, a grain) of
ſe rings be weighed, and the number then rec-
ned, the grain may be ſubdivided in any propor-
n, by dividing that number, and making the weights
al to as many of the rings as the quotient of the
iſion denotes. Then, if 750 of the rings amounted
a grain, and it were required to divide the grain
imally, downwards, $\frac{9}{10}$ would be equal to 675
gs, $\frac{8}{10}$ would be equal to 600 rings, $\frac{7}{10}$ to 525
gs, &c. Small weights may be made of thin leaf
ıſs. Jewellers foil is a good material for weights below
$\frac{1}{10}$ of a grain, as low as to the $\frac{1}{100}$ of a grain;
l all lower quantities may be either eſtimated by
poſition of the index, or ſhewn by actually count-

ing

ing the rings of wire, whoſe value has been deter- mined.

Number of weights required to form a ſet.

17. In philoſophical experiments, it will be found very convenient to admit no more than one dimenſio of weight. The grain is of that magnitude as to de- ſerve the preference. With regard to the number o weights the chemiſt ought to be provided with, writer have differed according to their habits and views. Ma thematicians have computed the leaſt poſſible numb with which all weights, within certain limits, migh be aſcertained; but their determination is of litt uſe, becauſe, with ſo ſmall a number, it muſt ofte happen, that the ſcales will be heavily loaded wit weights, on each ſide, put in with a view only to d termine the difference between them. It is not th leaſt poſſible number of weights which it is neceſſary a operator ſhould buy to effect his purpoſe, that we oug to enquire after, but the moſt convenient number f obtaining the reſults with accuracy and expeditio The error of adjuſtment is the leaſt poſſible, wh only one weight is in the ſcale; that is, a ſing weight of five grains is twice as likely to be true, two weights, one of three, and the other of tw grains, put into the diſh to ſupply the place of t ſingle five, becauſe each of theſe laſt has its own p bability of error in adjuſtment. But, ſince it is as conſiſtent with convenience to provide a ſingle weig as it would be to have a ſingle character for ev number; and as we have nine characters, which uſe in rotation, to expreſs higher values according their poſition; it will be found very ſerviceable to m the ſet of weights correſpond with our numer

ſyſt

THE BALANCE.

Decimal ſet of weights.

ſtem. This directs us to the ſet of weights, as fol- ws: 1000 grains, 900 g. 800 g. 700 g. 600 g. 500 g. o g. 300 g. 200 g. 100 g. 90 g. 80 g. 70 g. 60 g. g. 40 g. 30 g. 20 g. 10 g. 9 g. 8 g. 7 g. 6 g. 5 g. g. 3 g. 2 g. 1 g. $\frac{9}{10}$ g. $\frac{8}{10}$ g. $\frac{7}{10}$ g. $\frac{6}{10}$ g. $\frac{5}{10}$ g. $\frac{4}{10}$ g. g. $\frac{2}{10}$ g. $\frac{1}{10}$ g. $\frac{9}{100}$ g. $\frac{8}{100}$ g. $\frac{7}{100}$ g. $\frac{6}{100}$ g. $\frac{5}{100}$ g. g. $\frac{3}{100}$ g. $\frac{2}{100}$ g. $\frac{1}{100}$ g. With theſe the philoſo- ıer will always have the ſame number of weights in s ſcales as there are figures in the number expreſſing e weights in grains.

Thus 742.5 grains will be weighed by the weights o, 40, 2, and $\frac{5}{10}$.

Account of ſome balances.

I ſhall conclude this chapter with an account of me balances I have ſeen or heard of, and annex a ble of the correſpondence of weights of different untries.

The balance of Muſchenbroek:

Muſchenbroek, in his Cours de Phyſique (French nſlation, Paris, 1769), tom. ii. p. 247, ſays, he d an ocular balance of great accuracy, which turned ebuchoit) with $\frac{1}{40}$ of a grain. The ſubſtances he ighed were between 200 and 300 grains. His ba- ce, therefore, weighed to the $\frac{1}{12000}$ part of the ole; and would aſcertain ſuch weights truly to four ces of figures.

— of Bolton.

In the Philoſophical Tranſactions, vol. lxvi. p. 509, ntion is made of two accurate balances of Mr. lton; and it is ſaid that one would weigh a pound, l turn with $\frac{1}{10}$ of a grain. This, if the pound be irdupois, is $\frac{1}{70000}$ of the weight; and ſhews that balance could be well depended on to four places figures, and probably to five. The other weighed

half

half an ounce, and turned with the $\frac{1}{100}$ of a grain. This is the $\frac{1}{24000}$ of the weight.

Balance of Mr. Read:

In the ſame ſame volume, p. 511, a balance of Mr. Read's is mentioned, which readily turned with leſs than one pennyweight, when loaded with 55 pounds, before the Royal Society; but very diſtinctly turned with four grains when tried more patiently. This is about the $\frac{1}{96000}$ part of the weight; and therefore this balance may be depended on to five places of figures.

—of Mr. Whitehurſt:

Alſo, p. 576, a balance of Mr. Whitehurſt's weighs one pennyweight, and is ſenſibly affected with the $\frac{1}{2000}$ of a grain. This is $\frac{1}{48000}$ part of the weight.

—of the Author:

I have a pair of ſcales of the common conſtruction, § 8, made expreſsly for me by a ſkilful workman in London. With 1200 grains in each ſcale, it turns with $\frac{1}{70}$ of a grain. This is the $\frac{1}{84000}$ of the whole; and therefore about this weight may be known to five places of figures. The proportional delicacy is leſs in greater weights. The beam will bear near a pound troy, and when the ſcales are empty it is affected by the $\frac{1}{1000}$ of a grain. On the whole, it may be uſefully applied to determine all weights between 100 grains and 4000 grains to four places of figures.

—of Mr. Alchorne:

A balance belonging to Mr. Alchorne, of the Mint in London, is mentioned, vol. lxxvii. p. 205 of th Philoſophical Tranſactions. It is true to 3 grains wit 15 lb. an end. If theſe were avoirdupois pounds, th weight is known to $\frac{1}{35000}$ part, or to four places o figures, or barely five.

—of Dr. Geo. Fordyce.

A balance (made by Ramſden, and turning on poin inſtead of edges) in the poſſeſſion of Dr. George Fo

dyc

yce, is mentioned in the 75th volume of the Philo-phical Tranſactions. With a load of four or five unces, a difference of one diviſion in the index was ade by the $\frac{1}{1600}$ of a grain. This is $\frac{1}{384000}$ part of e weight; and, conſequently, this beam will aſcertain ch weights to five places of figures, beſides an eſti-ate figure.

The balance of Mr. Magellan:

I have ſeen a ſtrong balance in the poſſeſſion of y friend Mr. Magellan, of the kind mentioned in 15, which would bear ſeveral pounds, and ſhewed $\frac{1}{0}$ grain, with one pound an end. This is the $\frac{1}{0000}$ of the weight, and anſwers to five figures. But think it would have done more by a more patient ial than I had time to make.

—of the Royal Society.

The Royal Society's balance, which was lately ade by Ramſden, turns on ſteel edges upon planes of oliſhed cryſtal. I was aſſured that it aſcertained a eight to the ſeven millionth part. I was not pre-nt at this trial, which muſt have required great care nd patience, as the point of ſuſpenſion could not have oved over much more than $\frac{2}{100}$ of an inch in the rſt half minute: but, from ſome trials which I ſaw, I ink it probable that it may be uſed in general practice determine weights to five places and better.

Inferences.

From this account of balances the young ſtudent ay form a proper eſtimate of the value of thoſe bles of ſpecific gravities, which are carried to five, x, and even ſeven places of figures, and likewiſe of he theoretical deductions in chemiſtry that depend on ſuppoſed accuracy in weighing, which practice does ot authoriſe. In general, where weights are given o five places of figures, the laſt figure is an eſtimate or gueſs figure; and where they are carried farther, it may be taken for granted that the author deceives either intentionally, or from want of ſkill in reducing his weights to fractional expreſſions, or otherwiſe.

Compariſon of weights:

Among the numerous public exertions which our learned neighbours, the French, have made in favour of the ſciences, the determination of the relative proportions of the weights uſed in various parts of Europe, is by no means one of the leaſt. The moſt exact ſtandard weights were procured by means of the ambaſſadors of France, reſident in the various places; and theſe were compared by Monſ. Tillet with the ſtandard mark in the pile called the *poids de Charlemagne*, preſerved in the Cour de Monnoies at Paris. His experiments were made with an exact balance made to weigh one mark, and ſenſible to one quarter of a grain. Now, as the mark contains 18,432 quarter grains, it follows that his balance was a good one, and would exhibit proportions to four places, and a gueſs figure. The reſults are contained in Table II. (Appendix), extracted from Monſ. Tillet's excellent Paper in the Memoirs of the Royal Academy of Sciences for the year 1767. I have added the two laſt columns, which ſhew the number of French and Engliſh grains contained in the compound quantities againſt which they ſtand. The Engliſh grains are computed to one-tenth of a grain, though the accuracy of weighing came no nearer than about two tenths.

—by Monſ. Tillet.

CHAP.

CHAP. VII.

N THE ATTRACTIONS EXERTED BETWEEN BODIES; PARTICULARLY THOSE WHICH THE CHEMISTS CALL ELECTIVE ATTRACTIONS.

AFFECTIONS OF BODIES.

Great importance of the knowledge of the actions between the parts of bodies.

THUS far we have attended chiefly to the changes produced in bodies by an alteration in their temerature, and to the methods of conducting chemical perations. We now proceed to conſider thoſe actions vhich take place between the parts of bodies of diffeent kinds. Theſe form a branch of knowledge of the greateſt importance, but of ſuch an extended nature is to require the utmoſt caution to avoid error in enleavouring to acquire it. The whole ſcientific part f chemiſtry depends on a right interpretation of facts f this kind. In the inveſtigation of thoſe general truths vhich may be conſidered as laws of nature, we cannot herefore be too careful in diſtinguiſhing well-eſtabliſhed facts from the ingenious though inadequate concluſions which theoretical writers are too ready to form.

Inertia of matter.

Extenſion.

That property of matter or body by which we think we can beſt determine its quantity, is its inertia, or the reſiſtance it makes to the communication of motion. We cannot perhaps form any idea why there ſhould be more difficulty in moving one body than another, except that it really conſiſts of a larger portion of matter. The perceptible extenſion of the ſame body will vary, Gravity may perhaps be modified:

if the dimenſions of its pores be either increaſed or diminiſhed; and there is no inconſiſtency in ſuppoſing it at leaſt poſſible that its weight, or the force by which it is urged towards the earth, may not in all caſes continue unaltered, but be capable of modification like the attractions of magnetiſm and electricity. Neither the extenſion nor the weight of bodies appears therefore to be original meaſures of their quantities of matter; how far they may be uſed as ſuch, muſt depend on their coincidence with the inertia.

—but is not found to vary in experiments.

After a proper allowance has been made for the effects of the earth's rotation on its axis, it is found that the power of gravitation, in giving motion to the balls of pendulums, is accurately in proportion to their maſſes, as meaſured by their reſiſtance or inertia. The weights of bodies therefore are meaſures of their quantities of matter; and though the forces with which various bodies of equal magnitude are urged towards the earth, are different, we do not ſuppoſe the attraction or affinity between thoſe bodies and the earth to be ſtronger or weaker in the ſeveral inſtances, but only that the maſſes are greater or leſs. Thus, though a cubic inch of gold weighs more than twice as much as a cubic inch of copper, we do not ſuppoſe a ſtronger attraction between gold and the earth; but conclude that one general force acts on both, whoſe effects are greater on the former body than the latter, becauſe the maſs of the former is really greater than that of the latter.

Uſual inference.

Effects of attraction:

—cohesive.

The effects of attraction between one body and another are ſo numerous, that we cannot avoid perceiving them every moment. Two ſmooth poliſhed pieces of metal adhere when preſſed together. Water and other luids take the form of globules, and will ſtick to arious bodies, and paſs into the pores of ſponge, bread, r the cavities of ſmall tubes. Solid bodies retain their orm by the adheſion of their parts; and without this ower it is impoſſible to conceive how the univerſe ould, for a moment, ſubſiſt in its preſent form.'

Coheſive attraction differs from gravity.

It may be queſtioned whether this coheſive attraction e the ſame power as gravity. ' To decide the enquiry, t will be neceſſary to compare their manner of action. The force of gravity acts in the inverſe proportion of he ſquare of the diſtance between the bodies: but the ffects of coheſion are found to increaſe at a much faſter rate, as the bodies approach; ſo that its power is incomparably greateſt at ſmall diſtances. This ſeems to e a ſufficient reaſon for conſidering gravitation and oheſion as two diſtinct powers.

Elective attraction.

The elective attraction of the chemiſts—ſuch, for exmple, as when copper, being diſſolved in an acid, is eparated, and falls to the bottom in a powdery form, n the addition of iron—may, in all its numerous varities, be either one general power, acting like gravity, ccording to the maſſes or denſities of the particles; or it nay, like magnetiſm, be dependent more on the peculiar ualities of thoſe particles than on their maſſes. If the ormer were the caſe, we might ſimplify our deducions by admitting that coheſion and elective attraction re the ſame thing. It will be eaſy to examine whether his poſition will, in any one inſtance, lead us into an rror; and, if it does, it muſt be abandoned. Spirit of wine diſſolves reſin; water does not: hence it will ollow, if the attraction depend on the denſity of particles,

Queſtion.

CHEMICAL ATTRACTIONS.

Elective attraction does not depend on denſity.

ticles, that the particles of ſpirit of wine are denſer than thoſe of water. But, again, water diſſolves gums; ſpirit does not: whence, by the ſame reaſoning, we ſhould deduce, that the particles of water are denſeſt. But the true inference is, that if theſe different effects depend on any general law, it does not follow the denſity of the particles; and till that general law is diſcovered, we ought to conſider the various attractions which occur in chemiſtry, as peculiar to the bodies in which they are obſerved.

—probably on figure.

Bergman, Morveau, and other eminent chemiſts, are inclined to the opinion that there is but one general power of attraction in nature, which is modified chiefly by the figure of particles when extremely near each other. But this has not been ſtrictly examined.

Aggregation.

The adheſion of parts of the ſame kind, is called aggregation. Thus, a number of pieces of brimſtone united by fuſion, form an aggregate. The union of bodies of different kinds, in a groſs way, is called mixture. Thus ſand and ſalt of tartar may be mixed together. But when the very minute parts of one body unite with thoſe of another ſo intimately as to form a body which has properties different from thoſe of either of them, the union is called combination, or compoſition. For example, ſand and ſalt of tartar, expoſed to a ſtrong heat, combine, and form a compound called glaſs. The minuteſt parts into which an aggregate can be imagined to be divided without decompoſition, are called integrant parts; but the parts into which it is divided by decompoſition, are called component parts or principles.

Mixture.

Combination, or compoſition.

Integrant and component parts.

Principle

Elements, or firſt principles.

Principles which cannot be ſubdivided by art, are alled elements, or firſt principles; and the principles nade up of theſe, are called ſecondary principles. Some vriters carry this order ſtill farther; but it muſt be coneſſed that no means have yet been deviſed to ſhew uneuivocally whether any ſuch ſubordination of principles xiſts. We may indeed diſcover the component parts of odies; but we know nothing of their arrangement.

Heat.

See pag. 2, 3.

As the chemical attractions, like other powers of the ame kind, are weaker, the greater the diſtance beween the parts which act on each other; and as heat nlarges the dimenſions of the bodies; doubtleſs, by eparating their parts, it will not be difficult to explain he effect of heat upon the changes produced in bodies y their elective attractions.

Simple combination.

If two ſolid bodies, diſpoſed to combine together, be rought into contact with each other, the particles that ouch will combine, and form a compound; and the roceſs will go no further, if the compound ſtill retain he ſolid form. But if the compound be of ſuch a nature s to have its point of congelation or ſolidity much lower han the temperature in which the experiment is made, r if it attract water from the atmoſphere, it will be uid; and the eſſential property of a fluid being, that ll its particles may freely move amongſt each other, he parts of each body will be at liberty to move in ucceſſion, ſo as beſt to obey the elective attraction. The conſequence will be, that a new compound, in a luid form, will be produced by the union of the two odies. An inſtance of this has already been ſhewn n the mixture of ice and ſalt.

Page 19.

Suſpenſion.

If one of the two bodies be fluid at the temperature

Solvent, or menſtruum.

of the experiment, its parts will ſucceſſively unite with the parts of the ſolid, which will y that means be ſuſpended in the fluid, and diſappear. Such a fluid is called a ſolvent, or menſtruum, and the ſolid body is ſaid to be diſſolved. Thus water diſſolves ſalt, mercury diſſolves gold, glaſs of lead diſſolves ſand, &c.

Water.

Cauſe of error in eſtimating the attractions.

In the humid way, where the fluid ſtate is produced by means of water, and in many caſes of which the diſſolved bodies may be recovered by evaporating the water, it is uſual to attend only to the actions of the ſuſpended bodies, and neglect the fluid, becauſe common to all experiments of this kind. But as the water certainly has as great a ſhare in modifying the effect which follows, as any other of the bodies preſent, the elective attractions between bodies held in ſolution in water, will not in general be the ſame as when the menſtruum is ſpirit, oil, or æther; or when, in the dry way, one of the bodies is rendered fluid by ſtrong heat.

Limits of ſaturation:

— in fluids:

Some ſubſtances unite in all proportions. Such, for example, are acids in general, and ſome other ſalts with water; and many of the metals with each other But there are likewiſe many ſubſtances which cannot be diſſolved in a fluid, at a ſettled temperature, in any quantity beyond a certain proportion. Thus water will diſſolve only about one fourth of its weight o common ſalt; and if more be added, it will remain ſolid. A fluid which holds in ſolution as much o any ſubſtance as it can diſſolve, is ſaid to be ſaturate with it. But ſaturation with one ſubſtance does no deprive the fluid of its power of acting on and diſ ſolving ſome other bodies, but in many caſes increaſe th hat power. For example, water, ſaturated with ſalt, vill diſſolve ſugar; and water, ſaturated with fixed air, vill diſſolve iron, though, without that addition, its ction on that metal is ſcarcely perceptible. The word aturation is likewiſe uſed in another ſenſe by chemiſts: he union of two principles produces a body whoſe roperties are different from thoſe of its component arts, but which reſemble thoſe of the predominatng principle. When the principles are in ſuch proportion as that neither may predominate, they are ſaid to be ſaturated with each other; but if otherwiſe, the moſt predominant principle is ſaid to be underſaturated, and the other over-ſaturated.

— in general.

Solution aſſiſted by heat.

Fluids in general diſſolve a greater quantity of any ſubſtance the higher the temperature. This probably ariſes from the fluidity of the body in ſolution being promoted by the heat.

Medium of combination.

When two bodies, which would not otherwiſe combine, are made to unite by the addition of a third, the latter is called a medium. Thus the iron and water, in the inſtance lately mentioned, are ſaid to have combined by the medium of fixed air.

Separation, or precipitation.

It often happens, on the contrary, that the tendency to combination between a ſolvent and another body, is weakened or deſtroyed by the addition of a third. Thus ſpirit of wine weakens the action of water upon moſt ſalts, and of courſe ſeparates them from it. If to a ſaturated ſolution of nitre in water there be added an equal meaſure of ſtrong ardent ſpirit, the nitre becomes ſolid, and falls down in an inſtant to the bottom of the phial. The ſubſtance thrown down from a ſolvent by the addition of any other matter, is ſaid to be

CHEMICAL ATTRACTIONS.

be precipitated, and many ſuch products are called precipitates.

Simple elective attraction.

When a compound of two principles is ſo affected by the addition of a third, that a new compound is formed of this laſt principle and one of the other two; at the ſame time that the principle which was part of the original compound, but does not enter into the ſecond combination, is diſengaged; the decompoſition and new combination are ſaid to be produced by ſimple elective attraction or affinity.

Examples of ſimple elective attraction:

Moſt operations of nature or art are ſo complex, that it is exceedingly difficult to exemplify theſe effects. The following inſtance will exhibit an effect of ſimple elective attraction, if we overlook the effect of the water, which is preſent in both ſalts. Common ſalt conſiſts of two principles. The one is the mineral alkali commonly known by the name of ſalt of ſoda; and the other is the marine acid, which, when combined with water, is known by the name of ſpirit of ſalt. If the vitriolic acid be poured upon common ſalt, it will attract the alkali more ſtrongly than it is attracted by the marine acid. The conſequence will be, that it will unite with the alkali, and form a new compound, called Glauber's ſalt, while the marine acid flies off in the form of air. This air, meeting with moiſture in the atmoſphere, combines with it, and forms the common marine acid viſible in the form of white fumes.

— in the humid way:

— in the dry way.

In the dry way, if a combination of lead and ſulphur be fuſed with iron, the ſulphur unites with this laſt, and leaves the lead free.

If we were to ſpeculate on theſe events, it would be be eaſy to ſhew from what ſuppoſed action among the particles they may happen. If a particle of alkali be ſurrounded by particles of marine acid, and the vitriolic acid be added, the particles of theſe laſt may be ſo ſtrongly attracted by the alkali as to approach it, and remove the particles of marine acid beyond the limit of ſenſible attraction. This effect may be facilitated by the action of heat, which increaſes the diſtances between parts of bodies; and the diſengaged ſubſtance may aſſume either the ſolid, fluid, vaporous, or aerial ſtate, according to the temperature and the peculiar properties of the body itſelf in that reſpect.

Double elective attraction.

Where two bodies, each conſiſting of two principles, are ſo diſpoſed as to act on each other, and the order of the principles changes in ſuch a manner as to form two other bodies compoſed of different principles, the change is ſaid to be produced by double affinity, or double elective attraction.

Example: in the humid way:

In the humid way: Let mercury be diſſolved in the nitrous acid (or ſpirit of nitre of the ſhops) until the acid will take up no more. The ſolution will then conſiſt of a mercurial ſalt diſſolved in water. Let tartar, which is a ſalt conſiſting of a peculiar acid united with the vegetable alkali, be added. The conſequence will be, that the alkali of the tartar will quit its own acid, and, uniting with the nitrous acid, will form nitre, which will continue diſſolved; and, on the other hand, the acid of the tartar, being diſengaged, will unite itſelf to the mercury, and form a ſalt, which, on account of its inſolubility, will fall down in the form of a powder.

— dry way.

In the dry way: If an alloy of gold and copper be fuſed

fuſed with the antimony of the ſhops, which conſiſts of ſulphur and a metallic body called regulus of antimony, the ſulphur will unite with the copper, and float above, while the gold and the regulus combine together, and occupy the lower part of the crucible.

Numerical expreſſion of affinity.

One of the principal objects of chemical reſearch conſiſts in the numerical expreſſion of the attractive powers of bodies. If this were well aſcertained, it is probable we ſhould be able to foretel, not only the effects of ſimple or double affinity, but likewiſe in what caſes the compounds of three or more ſubſtances take place. See Appendix.

Mechanical properties of bodies do not follow the properties of their component parts.

No regular connection has been yet diſcovered between the ſolubility in water, the fuſibility, volatility, ſpecific gravity, and other obvious properties of the component parts of bodies, and of the compounds they produce. Hence it happens, in humid operations, that the inſoluble products will either fall to the bottom, or riſe to the ſurface, according to their weights. In ſome proceſſes, all the products will be thus ſeparated; and in others the whole will remain diſſolved. In the dry way likewiſe ſome products will riſe, other will become fluid, and others fixed, ſo as to require a ſtronger heat to fuſe them than before.

Utility of theſe changes.

Theſe ſeveral changes afford means to the chemiſt o ſeparating bodies from each other. When two different kinds of ſalt are diſſolved in water, it would be almoſt impoſſible to ſeparate them if they were both equally ſoluble; becauſe evaporation would leave both in a confuſed maſs. But where the one is more ſoluble than the other, the latter will begin to be ſeparated and may be taken out at a period of the evaporation, a

whic

CHEMICAL ATTRACTIONS.

hich the whole of the former will remain ſuſpended. likewiſe the advantages derived from the proceſſes diſtillation, ſublimation, and other dry operations, founded on theſe different properties of bodies.

Cryſtallization.

The parts of all bodies which take the ſolid ſtate diſpoſed to arrange themſelves in ſuch a manner as produce ſome regular geometrical figure in the ſolid. ius ice, during its formation in water, or even in open air, always aſſumes a regular figure, as far circumſtances will permit. The ſame is obſervable the fixation of other fluids, and alſo in the ſepa- tion of bodies from their ſolvents, as ſalts from ıter. This property is called cryſtallization, and regularly-figured bodies are called cryſtals. The ure of cryſtals is influenced by ſo many circum- ınces—ſuch as the quickneſs of their formation, the nperature and agitation of the fluid, the preſence of ht, and others—that little dependence can be placed it as an indication of the compoſition of bodies; ough the experienced operator will doubtleſs derive ne advantage by attending to it.

Polarity of the particles of bodies.

The regular arrangement of parts in cryſtallization ſuppoſed by ſome to be the conſequence of a pro- rty in the particles of bodies, ſimilar to polarity in ıgnetiſm. And indeed it ſeems reaſonable to infer, ıt two compounded particles, coming together by raction, undiſturbed by any other cauſe, ſhould diſ- ſe themſelves ſo as to apply ſuch ſides of each gether, as are occupied by principles the moſt ractive of each other.

BOOK II.

ARTICULAR CHEMISTRY.

SECTION I.

F THE GENERAL PRINCIPLES OF BODIES.

CHAP. I.

NCERNING THE GENERAL DIVISION OF CHEMICAL PRINCIPLES.

Arrangement.

AMONG the various diviſions or arrangements of chemical principles, that which follows their ſpective degrees of ſimplicity muſt undoubtedly prove e moſt uſeful, becauſe the more compounded bodies ll eaſily aſſume a regular order when their reſpective inciples are known and properly claſſed. There is wever a limit in the advantages that may be derived en from this method of diviſion. The more we ceed in ſimplifying the principles of bodies, the re difficult it is to determine truly what paſſes in chemical

Arrangement.

chemical operations; becauſe theſe principles, when in their moſt diſtinct ſtate, have the aerial form, and cannot therefore be managed or weighed without conſiderable difficulty. From this cauſe it is that, while we have no diſputes concerning the changes of combination in groſſer and leſs ſimple ſubſtances, the moſt eminent chemiſts often differ in their opinions concerning the tranſitions of firſt principles from one combination to another; and are not agreed concerning the exiſtence of ſome of them. The peculiar properties of bodies may be changed, either by the addition o ſubtraction of ſome of their component parts; and it i eaſy to form a notion that ſuch a change may alſ happen by a mere alteration in the diſpoſition or relativ arrangements of their parts, without any change i their quantities. To determine which of theſe events takes place, when we behold only the conſequen change, is ſometimes impracticable, for want of a ſuff cient number of facts; and in moſt caſes the comple inveſtigation requires the unprejudiced and patient e ertion of all the powers of the mind. It will b proper therefore, in an elementary arrangement, to f our attention chiefly on the moſt palpable compone parts of bodies, which are ſufficiently ſimple; an where they are not the ſimpleſt, to ſpeak of their pri ciples in the analytical method.

Enumeration.

The component parts of bodies are either,

1. Principles whoſe exiſtence is doubtful: theſe a heat, light, and phlogiſton.

2. Principles which have not been exhibited in ſolid or fluid ſtate, or diſſolved in water, in any nota

proporti

Enumeration.

proportion: theſe are vital air, phlogiſticated air, and inflammable air.

3. Water.

4. Earths.

5. Alkalis.

6. Acids.

7. Metals.

8. Mineral combuſtibles.

9. Parts of organized ſubſtances, whether obtained by mechanical preſſure, by ſimple ſolution in water or ardent ſpirit, by a gentle or a ſtrong heat, by the action of ſolvents, or by ſpontaneous decompoſition.

Animal, vegetable, and mineral kingdoms.

The only general diviſion of bodies at preſent referred to in the writings of modern chemiſts, is that by which they are claſſed into three kingdoms, called the animal, vegetable, and mineral kingdoms. The kind of bodies arranged in the two firſt kingdoms is obvious from the terms; and all other bodies are conſidered as belonging to the mineral kingdom.

Salts.

Alkalis, acids, and ſuch compounds as they enter into, are diſtinguiſhed generally by the name of ſalts. The leading character of ſalts is a ſtrong tendency to combination, there being no bodies in nature which are not acted upon by ſome ſaline ſubſtance. This tendency appears in their eminent degree of ſolubility in water. All bodies known only by the name of ſalts, are ſoluble in leſs than two hundred times their weight of boiling water. The ſame cauſe produces their ſapidity, or taſte, which was regarded by the earlier chemiſts as a diſtinctive character of ſalts.

Metals are ſometimes claſſed with combuſtible bodies; and, ſtrictly ſpeaking, they are combuſtible. But

PRINCIPLES OF BODIES. Metals.

as none of them poſſeſs this property in ſuch a degree as to burn away in the common air, without the co-operation of other inflammable bodies, which are neceſſary to maintain their high temperature; and as they poſſeſs other remarkable properties peculiar to themſelves—they require to be placed in a ſeparate claſs.

CHAP. II.

ONCERNING HEAT, LIGHT, AND PHLOGISTON, CONSIDERED AS COMPONENT PARTS OF BODIES.

DOUBTFUL PRINCIPLES.

Heat. Page 6. 21.

IT has already been ſtated, that the exiſtence of heat, as a peculiar ſubſtance, is not proved; and, among hiloſophers of the firſt eminence, there are ſeveral who hink the opinion that it is a mere modification, is the noſt probable. With regard to light, the opinions of he world are leſs divided. It is generally taken for granted that light is a ſubſtance, or an emanation of particles of prodigious minuteneſs, which are projected n right lines, with extreme velocity, from luminous bodies; and that they are repelled from all bodies at certain diſtances, and at leſs diſtances attracted, ſo as o produce all the effects of reflection, refraction, and nflection, in the rays they compoſe. Theſe particles are ſuppoſed to be either of various magnitudes, or differently acted on by other bodies, and from that cauſe to be ſeparable from each other; in which ſeparate ſtate they affect the organ of ſight with the ſenſation of various colours.

Light.

Newton's Optics, ſub fine.

Subtle fluid.

Many philoſophical writers have conſidered it as an axiom, that a body cannot act where it is not*; and have

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* It may be obſerved that this poſition is very doubtful. All our knowledge is derived from an obſervation of the actions which take place between bodies. Now we never ſee bodies act where

DOUBTFUL PRINCIPLES.

Light.

have thence inferred, that the univerſe is occupied by a ſubtle fluid, whoſe action cauſes bodies to approach and recede from each other in the phenomena of attraction and repulſion. Light is conſidered by ſome authors* as a modification of this fluid, in the ſame manner as ſound is admitted to conſiſt in an undulatory motion of the air, communicated from ſonorous bodies. We ſhall not here examine the merits of this queſtion, but ſhall only obſerve, that no deciſive experiments have yet been offered in ſupport of either opinion.

Burning lens, or mirror.

When a great number of rays of light are made, either by a burning glaſs or concave ſpeculum, to paſs through a ſmall ſpace, they excite a moſt powerful heat in bodies placed in the focus. The ſtrongeſt heat yet known is of this kind. The heat produced in bodies by the action of light, is in general greater, the more light is cauſed to diſappear. Bodies which either tranſmit or reflect the light in large quantities, are very little heated by the focus of a burning apparatus. Similar coatings of black paint, the one upon a plate of iron, and the other upon a plate of paſteboard, being expoſed in circumſtances perfectly ſimilar to the ſun's rays, the heat produced was greater in the iron, though the maſs

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where they are, but always where they are not. In attraction and repulſion this is evident; and in impulſe, there are the beſt reaſons to conclude that the impelling body approaches within a certain diſtance of the impelled body, and then acts by its repulſive force without contact. Even the particles of bodies do not touch; for, if they did, how could a diminution of temperature bring them nearer together? Of the penetrability of matter we need not ſpeak in this place.

[*] Of theſe the great Euler ſtands firſt. See his Letters to a German Princeſs.

of

f this laſt was near ten times that of the paſteboard*.

Light and heat differ.

has been often aſſerted, that heat and light are the
me thing. But the light of a fire will paſs through a
ne of glaſs, and the heat will remain behind, as is moſt
idently ſhewn by interpoſing the glaſs between the
e and a concave metallic mirror†. The focus of the
irror, though as luminous as before, will produce no
at. A bright table-ſpoon may be uſed where a mirror
not at hand. The preſence of light has a conſiderable
fect upon the proceſs of cryſtallization; and in many
ſtances it produces a change in bodies of an oppoſite
ture to that which they ſuffer from combuſtion.

Phlogiſton.

During the combuſtion of inflammable bodies, we
rceive a continual eſcape of volatile matter; and as
e fixed reſidue is uſually found to be much leſs than
e original weight of the body which has been burned,
was natural for the earlier chemiſts, who were unac-
ainted with the nature and quantity of the volatile
oducts, to infer that combuſtion conſiſted in the eſcape
ſome principle which inflammable bodies poſſeſſed,
it which was wanting in ſuch as could not be burned.
his doctrine has been occaſionally modified till our
me; and the experiments made by expoſing to heat a
etal that had been burned, together with another
ore inflammable body, in a cloſed veſſel, in which
e latter was conſumed, while the former recovered its
flammability, were, till lately, received as undoubted
roofs that the principle of inflammability or phlogiſton

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* Dr. George Fordyce, in Phil. Tranſ. Vol. LXXVII. p. 313.

† Scheele on Air and Fire, p. 70. Engliſh tranſlation.

DOUBTFUL PRINCIPLES.

Phlogiſton.

had paſſed from the one body to the other. It was indeed urged as an objection, that metallic bodies, ſo far from loſing weight by calcination, do really become heavier: and later experiments ſhewed that this increaſe of weight was gained from the air; the abſolute neceſſity of whoſe preſence in combuſtion had been formerl either overlooked, or ſlightly regarded. But this wa explained from the doctrine of affinity, by the ſuppoſition that the pure air of the atmoſphere, combinin with the baſe of the combuſtible body, ſet its phlogiſton or fire, at liberty. The modern doctrine of heat however appears to ſhew, that the increaſe of temperatur ariſes from the air, and not from the combuſtible body and this conſideration has led ſeveral eminent Frenc chemiſts to reject phlogiſton altogether*, and to conſider the proceſs of combuſtion as nothing elſe but th act of combination of vital air with the combuſtibl body; the matter of heat, which according to the is combined with the air, being ſet at liberty. Page 33.

Among the chemiſts who maintained the old opinion it became therefore an object of enquiry, whether the air abſorbed in combuſtion really eithe expels, or combines with, any principle common to a inflammable bodies. For if this ſhould be reſolved i the affirmative, the ſubſtance found would be th

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[*] This doctrine may be ſeen diſplayed at length in the no annexed to Kirwan's Eſſay on Phlogiſton, ſecond edition. M Lavoiſier is the firſt of the chemiſts who explained and illuſtrat the new doctrine by a ſet of accurate experiments, and a judicio arrangement of the known facts; but M. Bayen may be conſider as the firſt modern who, upon rational grounds, rejected the phl giſton. The excellent John Mayow is the father of this doctri

DOUBTFUL PRINCIPLES.

Phlogiſton.

ınciple of inflammability or phlogiſton. The evident y to determine this muſt be, to heat combuſtible lies in cloſed veſſels. The moſt predominant vola- product is, in theſe caſes, found to be a very light ial matter, which is very inflammable when com- n air is preſent; and is known by the name of in- nmable air. Mr. Kirwan firſt announced this as phlogiſton.

Queſtion.

Che great queſtion now is, whether inflammable be contained in all combuſtible bodies, ſince they not all emit it by mere heat; and it is evident that, combuſtion can be effected without it in any one ance, it cannot be the indiſpenſable and univerſal nciple of inflammability. Its exiſtence is denied in phur, phoſphorus, charcoal, metals, and ſome other ſtances. It may however be obtained by heating ſe, if water be preſent: whether it is afforded by ſubſtance under examination, or by the water, is refore the ſubject of controverſy.

Ve may reſume this ſubject as we advance; but ugh has been ſaid in this chapter to ſhew the learner t the exiſtence of heat, light, and phlogiſton, as mical principles of bodies, is not yet incontroverti- eſtabliſhed.

CHAP.

CHAP. III.

OF PHLOGISTICATED, DEPHLOGISTICATED OR VITA AND INFLAMMABLE AIR, AND OF THE COMPOSITION AND GENERAL PROPERTIES OF WATER.

COMBUSTION.

Page 50.

WHENEVER combuſtion, or an equivale
proceſs, is carried on in a veſſel containi
atmoſpherical air, which is incloſed either by inverti
the veſſel over mercury, or by ſtopping its apertu
in a proper manner, it is found that the proc
ceaſes after a certain time; and that the rema
ing air, which is about three-fourths of the wh
bulk, is of ſuch a nature, as to be incapable of ma
taining combuſtion, or ſupporting the life of anim

Effects of combuſtion on common air.

From this experiment it is clear that one of the f
lowing deductions muſt be true: 1. The combuſti
body has emitted ſome principle which, by combin
with the air, has rendered it unfit for the purpoſe
combuſtion: Or, 2. It has abſorbed part of the
which was fit for that purpoſe, and has left a reſi
which is of a different nature: Or, 3. Both events h
happened; namely, that the pure part of the air
been abſorbed, and a principle has been emitted wh
has changed the original properties of the remaind

Obſervations.

The facts muſt clear up theſe theories. The
cannot be altogether true, becauſe the reſidual ai
not only of leſs bulk, but of leſs ſpecific gravity,
the burned body is heavier than before. The
ca

Opinions.

nnot therefore have received ſo much as it has loſt.
ie ſecond is the doctrine of the philoſophers who
ny the exiſtence of phlogiſton, or a principle of in-
mmability. And the third muſt be adopted by thoſe
io maintain that ſuch a principle eſcapes from bodies
ring combuſtion. This reſidue was called phlo-
ſticated air, in conſequence of ſuch an opinion.

Phlogiſton.

In the opinion that inflammable air is the phlogiſton,
is not neceſſary to reject the ſecond deduction. For
ie pure or vital part of the air may unite with inflam-
iable air, ſuppoſed to be in a fixed ſtate in the com-
uſtible body; and if the product of this union remain
xed, it is plain that the reſidue of the air after com-
uſtion will be the ſame as it would have been if the
ital part had been abſorbed by any other fixed body.
)r if the vital air be abſorbed while the inflammable
ir is diſengaged, and unites with the aerial reſidue,
his reſidue will not be heavier than before, unleſs the
iflammable air it has gained exceeds in weight the
ital air it has loſt.

Compoſition of the atmoſphere.

It is rendered more probable that the air of the at-
noſphere conſiſts of a mixture of a vital and a noxious
)art, by the fact, that, when fixed bodies have been
)urned or calcined (for example, mercury converted
nto precipitate per ſe), the vital air may be again ex-
tricated from ſome of them. This is found to maintain
combuſtion in the moſt effectual manner, and is almoſt
totally abſorbed in that proceſs, inſtead of leaving a
reſidue ſuppoſed to be changed by phlogiſtication.
And, on the other hand, there is no unequivocal
proof that vital air can be obtained from the phlogiſti-
cated part by any operation whatever.

Vital

VITAL AIR.

Subſtances which afford vital air.

Vital air may be obtained by heat from nitre, from alum, from mercury calcined without addition, and uſually called precipitate per ſe; from red precipitate, from minium, from mangancſe, and from lapis calaminaris. Moſt nitrous and vitriolic ſalts afford it by heat. It is contained in the bladders of ſea-weed, and in waters. The green vegetable matter formed in water emits it when expoſed to the ſun's light; and it is found in general that the leaves of plants, in like circumſtances, emit vital air. Whence it appears that there are abundant proviſions for reſtoring the purity of the air, which is continually injured by combuſtion, reſpiration, fermentation, and other proceſſes.

Reſpiration is a proceſs of the ſame kind as combuſtion.

The reſpiration of animals produces the ſame effect on air as combuſtion does; and their conſtant heat appears to be an effect of the ſame nature. When an animal is included in a limited quantity of atmoſpherical air, it dies as ſoon as the air is vitiated. Vital air, in like circumſtances, maintains the life of animals much longer than common air.

Vegetables affect the air.

Vegetables do not thrive in vital air. Theſe appear to render common air purer, by abſorbing its phlogiſticated or noxious part. They emit vital air when the ſun ſhines on them. This is ſuppoſed to ariſe from the decompoſition of water.

Nitrous air uſed as a teſt.

Several of the metals, and other combuſtible ſubſtances, when diſſolved in ſpirit of nitre, afford or extricate, by an effervefcence, a kind of air called nitrous air, of which we ſhall more particularly ſpeak in its place. Mercury is one of theſe metals. If this air be mixed with any other air in which vital air is contained, it unites with this laſt, and forms red fumes, which

hich fall down, and are found to conſiſt of nitrous id. The air itſelf is diminiſhed in bulk by the loſs; d hence the nitrous air becomes a teſt of the good-ſs of reſpirable air. For the diminution is greater e greater the quantity of vital air.

Subſtances which afford inflammable air.

All animal or vegetable ſubſtances which can be rned in the open air, charcoal excepted, will afford flammable air, if heated in cloſed veſſels. This is ſually mixed with air of other kinds, and with leaginous matter. Charcoal and ſeveral metals afford flammable air by heat, if water be preſent. Some etallic ſubſtances, during their ſolution in acids, fford or extricate inflammable air, which is of the ureſt kind. This fluid is very light, according to s purity. It is uſually about ten times as light as an qual bulk of common air; but it is ſaid to have een obtained ſeventeen times lighter [*]. The common roceſs for obtaining it is, to diſſolve iron filings or avings in diluted vitriolic acid.

Water produced by combuſtion of vital and inflammable air.

If a mixture of about two parts, by meaſure, of flammable air, with one of vital air, be ſet on fire, a ſtrong cloſed veſſel, which may be done by the ectric ſpark, the airs, if pure, will almoſt totally ſappear, and the product will be water and an acid. ill lately, the produce was thought to be mere ater; and ſeveral eminent chemiſts at Paris have rongly inſiſted that it was equal in weight to the wo airs made uſe of. This agreement however as never been proved [†]; and, as every kind of air uſually

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[*] By Morveau. See the Aeroſtat de Dijon.

[†] When we conſider the great bulk and ſmall weight of air, e magnitude of the apparatus, and the imperfection of the beſt balances,

Whether water be a compound.

uſually holds a large proportion of water in ſolution from which the aqueous product might be derived, i ſtill remains a problem to be decided, whether water with reſpect to the preſent ſtate of our knowledge, b a ſimple or a compound ſubſtance. For the wat may either be formed by the union of the two air or the real airs may be totally employed in forming th acid, while the water is ſimply condenſed upon the loſing the aerial form.

The extenſive utility of water:

Water is a ſubſtance which enters into ſo many op rations of nature and art, that a full deſcription of i properties would include moſt of the properties of othe bodies. Its weight is uſed as the meaſure of ſpecifi gravity; its capacity for heat is aſſumed as the ſtandar of compariſon for other bodies; its temperature at tl changes from ſolidity to fluidity and to the elaſtic ſtat are taken as the fixed points for thermometers; an in a word, the ſolubility of bodies denotes, in genera the action which this ſubſtance exerts upon them.

—its general properties.

Page 18.

Water being uſually met with in theſe climates i the fluid ſtate, its properties are in moſt caſes treate of under that form. If it be heated it gradually ex pands, and is converted into vapour at 212° of Fahren heit, with ſuch rapidity as to counteract the effect o heat in raiſing its temperature. In a ſtrong cloſe metallic veſſel it may be heated nearly red hot, and i

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balances, none of which in practice weigh beyond five places figures (p. 67—69), we ſhall find ſufficient reaſons to queſtion t accuracy of concluſions, which ſuppoſe the quantities of air an water to be rigorouſly aſcertained. Theſe reaſons are ſtill mo enforced by the conſideration, that the experiments of Dr. Prieſtl and M. Lavoiſier do not agree.

General, properties of water.

ſtate its ſolvent powers are greatly increaſed. If the l be opened, ſteam ſuddenly ruſhes out, and the erature of the fluid falls inſtantly to 212°. When r is cooled, it gradually contracts till within 8° of ing, and then expands till it freezes. The parts e water which firſt become ſolid by freezing, have orm of ſword-blades, croſſing each other at angles 0 degrees. It will ſhoot out into this form in the air, as may be ſeen in ſnow or hoar froſt upon trees.

Ice.

is conſiderably lighter than water, and therefore s upon it. The expanſion of ice at the time of ormation is made with ſuch force as to burſt the geſt metallic veſſels: and the expanſion of ſteam rodigiouſly great. This laſt power, being very ageable, by transferring greater or leſs quantities of n into the veſſels of apparatus, or by condenſing as been applied to the moſt important mechanical in the ſteam engine, and will doubtleſs be applied any more.

Effects of the eolipile.

hen water is included in a metallic globe or veſſel, d the eolipile, which has only a very ſmall aperture, it is then made to boil, the ſteam iſſues out very ntly, and will ſtrongly urge a fire in the ſame ner as bellows. This has been thought to prove a mpoſition of the water. But it is not the ſteam h excites the fire, but the air it drives before it. an eolipile will not produce this, but the contrary t, unleſs a body of air be interpoſed between its ture and the fire *.

Denſity of water.

he denſity of water † is ſuch that a cubic foot

Lewis's Philoſophical Commerce of Arts, p. 21.

This was found by Cotes, who ſays it is very nearly ſo. is Hydroſtatical Lectures, p. 76, ſecond edition.

Specific gravity of water.

weighs 1000 ounces avoirdupois weight. This fortunate concurrence of unity of meaſure with a roun number in the weight, renders the common tables o ſpecific gravities very uſeful in computations. F the numbers will denote the avoirdupois ounces in cubic foot of each ſubſtance, provided the ſpeci gravity of water be taken to be 1000.

What waters are pureſt.

The pureſt common waters are the lighteſt, a lather well with ſoap. For chemical purpoſes, wat ſhould be boiled on a common fire for a ſhort time, diſſipate any volatile animal or vegetable impregnati it may poſſeſs, and afterwards diſtilled to about o half. The water which comes over is very pure, a the accurate chemiſt ſhould uſe no other. On accou of the extenſive uſe and importance of diſtilled wat it is adviſable not to perform this operation but w veſſels kept for that and no other purpoſe.

CHA

CHAP. IV.

OF THE SIMPLE OR PRIMITIVE EARTHS.

EARTHS.

HEMISTS diſtinguiſh ſuch ſubſtances by the name of pure earth, as are brittle, incombuſtible, ıſible by the heat of furnaces, not ſoluble in ſeveral ıdred times their weight of water, and deſtitute of tallic ſplendour. There are few earthy ſubſtances ich may not be reduced by analyſis to one of the following primitive earths :—the ſiliceous, argilla- us, calcareous, ponderous, and magneſian earths; ɔtherwiſe, taken ſubſtantively, they are called ſilex, , lime, barytes, and magneſia.

Five primitive earths.

The adamantine ſpar, the jargon of Ceylon, and a ıeral ſubſtance from New South Wales, have afford- earthy ſubſtances which, as far as experiments have determined, are different from any of theſe five. they will not materially affect the general arrange- nt of chemiſtry, until future reſearches ſhall have ved that they are more abundantly found than at ſent we have reaſon to ſuſpect.

New earths.

n ſome ſyſtems a diſtinction is made between earths l ſtones; but this is of no utility in the enquiry re- cting their component parts and properties. A ne is nothing more than a hard earthy maſs, and earth in powder is an aggregate of very minute nes.

Stones.

Siliceous earth abounds in all natural bodies which hard enough to ſtrike fire with ſteel. Of theſe,

Siliceous earth.

rock cryſtal, quartz, flint, gritſtone, jaſper, and mo
of the precious ſtones or gems, are the chief ſpecimen
Like all other ſimple ſubſtances, it is never found pu
in nature. The leading or principal character of th
earth is, that it is not perceptibly acted upon by a
acid but that of fluor ſpar. Alkalis diſſolve it in th
moiſt as well as in the dry way, but moſt efficaciou
and in all proportions in the latter. Hence the metho
of obtaining ſiliceous earth in a ſtate of purity conſi
in diſſolving cryſtal or quartz in a large proportion
fixed alkali in ſtrong fuſion: for example, four parts
weight of the ſalt to one of the earth. This comb
nation will unite with water, in which it muſt be d

Liquor of flints.

ſolved. The ſolution is uſually called liquor of flin
An exceſs of acid being added, will combine with th
alkali, and ſuch other earths as may have exiſted in th
natural ſpecimen; and the pure ſiliceous earth, bein
inſoluble in water, will fall to the bottom. Repeat
waſhing in diſtilled water will ſeparate all the extr
neous matter from theſe particles, which, when drie
conſiſt of ſiliceous earth uncombined with any oth
ſubſtance.

Pure ſiliceous earth.

The particles of ſiliceous earth, thus obtained, are
a ſtate of ſuch minute diviſion, that they will rema
ſuſpended for a conſiderable time in water; and th
fluid, violently heated in a ſtrong cloſed veſſel, will d
ſolve a portion of it. Siliceous earth is unalterable
the moſt violent heats chemiſtry can produce in a fu
nace. Rock cryſtal, which is the pureſt ſpecimen
this earth, of which it contains ninety-three parts in
hundred, has been fuſed by flame urged upon it by
ſtream of dephlogiſticated air from a blow-pipe. W

fix

EARTHS.

d alkalis, in the proportion of about double its own
ght, it forms glaſs. Calcined metals, eſpecially lead,
diſſolve it, and form glaſs by fuſion. The combi-
on of this earth with fluor acid is very ſparingly
ble in water.

Argillaceous earth.

'he principal natural ſpecimens of argillaceous earth
clays, properly ſo called, marles, boles, ſlates or
ſtus, and mica. In none of theſe, except the flag-
e, does the argillaceous earth amount to ſo much as
their weight, though their predominating qualities
ear to depend upon it. The moſt obvious cha-
ers of this earth are, an adheſion to the tongue, or
wet and ſoft body, in the more ſolid ſpecimens; and
markable tenacity, ductility, or kneadability ſerve to
inguiſh moiſtened clays in a moſt eminent degree.
; ſoluble in acids, but alkalis act much leſs upon it,
er in the dry or moiſt way, than they do on ſiliceous
h. Alum is a combination of argillaceous earth with
olic acid. If the concrete volatile alkali be added
ſolution of pure alum, the alkali and acid unite,
le the clay falls to the bottom, united only with a
ll quantity of fixed air. The fluid muſt be abſtracted
iecantation, and the precipitate waſhed with diſ-
d water, and dried.

Earth of alum.

Common clays.

'lays may be eaſily diffuſed and ſuſpended in water,
are not ſoluble in any ſenſible degree. The ſud-
application of ſtrong heat hardens their external
ts, which afterwards burſt by the exploſion of the
iſture within. By a more gradual heat, pure clay
tracts very much, becomes hard and full of cracks
iſſures. The preſence of ſiliceous earth in common

clays, where it uſually conſtitutes above half the weigh
renders the contraction more uniform throughout, an
prevents the cracks, probably in no other way than b
rendering them more numerous, and too ſmall to

Pottery.

perceived. When thus baked, it conſtitutes all th
varieties of bricks, pottery, and porcelain. Theſe,
baked in a ſtrong heat, give fire with ſteel; a proper
that may be attributed to the ſiliceous earth they con
tain, which cannot act on the ſteel unleſs firmly ſ
in the hardened clay. The dimenſions of pottery a
leſs, the greater the heat to which the article has be
ſubjected. On this property is conſtructed a th

Thermometer for ſtrong heat.

mometer for meaſuring the heat of furnaces, by igniti
a ſmall brick of known dimenſions therein, and aft
wards meaſuring its contraction*. Baked clay is
longer kneadable with water, though as finely pulv
rized as mechanical means can go. Hence it has be
inferred that clays owe their ductility to a kind
gluten which is ſuppoſed to be diſſipated by he
They recover that property however by ſolution in
acid and precipitation; whence it ſhould ſeem to d
pend either on a minute portion of acid contained
clays, or the ſmallneſs of the particles when preci
tated.

Calcareous earth:

Calcareous earth, or lime, predominates in m
ſtones which are ſoft enough to be ſcratched wit
knife. Theſe are chalk, limeſtone, marble, ſpars, g
ſum, or plaſter ſtone, and various others. As the li
is moſt frequently combined with fixed air, it is uſ
for mineraliſts to drop a ſmall quantity of nitrous a

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* See Wedgwood in Phil. Tranſ. Vol. LXXII. and LXXI

Method of obtaining it pure.

pon the ſtones they are deſirous of claſſing; and if it oths by the eſcape of the fixed air, they conclude that ne enters into the compoſition. To obtain pure cal- reous earth, powdered chalk muſt be repeatedly oiled in water, which will deprive it of the ſaline npurities it frequently contains. It muſt then be iſſolved in diſtilled vinegar, and precipitated by the ddition of concrete volatile alkali. The precipitate, hen well waſhed and dried, will conſiſt of lime nited to fixed air; the latter of which may be driven ff by heat, if neceſſary.

Lime, or quicklime.

Slaked lime.

If chalk, marble, limeſtone, ſpar, or any other ſpeci- nens of this earth, containing fixed air, be expoſed to ontinued ignition, they give out fixed air and wa- er, to the amount of near half their weight. The emainder, conſiſting chiefly of lime, has a ſtrong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very onſiderable heat, attended with noiſe, and agitation of the parts, which break aſunder; and a phoſphoric light is ſeen if the experiment be made in the dark. Lime thus ſaturated with water, is ſaid to be ſlaked. Water diſſolves about one ſeven hundredth part of its weight of lime, and is then called lime-water. This ſolution has an acrid taſte, and turns ſyrup of violets to a green colour. If lime-water be expoſed to the open air, the lime attracts fixed air, and is by that means converted into chalk; which, not being ſoluble in water, forms a cruſt on the ſurface, formerly called cream of lime, that, when of a certain thickneſs, breaks and falls to the bottom: and in this way the whole of the lime will in time be ſeparated.

Mortar.

The paſte of lime and water, called mortar, has a degree of adheſion and ductility, though much leſs than clay. When dry, it is friable like chalk. A mixture of ſand, or broken earthen veſſels, greatly increaſes its firmneſs, which it ſeems to effect by rendering it more difficult for the parts to be removed with reſpect to each other. When mortar is left to dry by the gradual evaporation of its ſuperfluous water, it is very long before it obtains its utmoſt degree of firmneſs. But if dry quick-lime be mixed with mortar, it gradually abſorbs the ſuperfluous water, and the maſs becomes ſolid in a very ſhort time.

Gypſum, or plaſter of Paris.

Gypſum, or plaſter of Paris, conſiſts of lime united to the vitriolic acid, together with water. If this ſubſtance be expoſed to a moderate heat, part of the water is driven off. The dry powder which remains may be mixed with water to the conſiſtence of thin paſte, and poured into a mould; and ſoon afterwards it ſuddenly becomes ſolid, at the ſame time that it is a little heated, and its bulk ſomewhat increaſed. This effect may be explained by obſerving that the particles of the gypſum are at firſt ſimply wetted by the water, in the ſame manner as happens with clay; and for that reaſon no other effect takes place, than the production of an imperfect degree of fluidity, from the motion of the parts among each other being facilitated: but when the water, by the gradual progreſs of the action between it and the dried gypſum, becomes combined in the ſame manner as before the calcination, it is abſorbed, and enters into the compoſition of a ſolid body; the imperfect fluidity, ariſing from the preſence of uncombined water, diſappears, heat is developed, and the

whole

EARTHS.

ıole maſs takes the ſolid form. The uſe of this ıterial for caſting ſmall ſtatues, medallions, and ıer ornaments, is well known.

Animal earth.

The earth which enters into the compoſition of the nes of animals and ſhells of fiſh is calcareous. In : former it is united with the phoſphoric acid, and the latter with fixed air.

Ponderous earth.

Ponderous earth, or barytes, is not found very abunntly, or in large continued maſſes, but chiefly in the :inity of mines, or veins of metal. Its ſpecimens are her aërated ponderous ſpar, which has been found Alſton Moor, in Cumberland [*], and conſiderably ſembles alum, but is of a ſtriated texture: or vitriıted ponderous earth, either in the form of a tranſrent ſpar or an opake earth; of a white, grey, or wn colour; frequently of no regular figure, but ten in the peculiar figure of a number of ſmall convex ıſes, ſet edgwiſe in a ground. The opake ſpecimens ve been called marmor metallicum, on account of :ir great weight; but the Engliſh miners call it cawk. oſt ſpecimens of this earth are above four times the :ight of an equal bulk of water, which conſtitutes an vious difference between this and calcareous earth, ıich is little more than twice that weight: they are

Ponderous ſpar, or marmor metallicum.

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[*] Analyſed by Dr. Withering. See Phil. Tranſ. Vol. LXXIV. Watt, jun. in the third volume of the Mancheſter Memoirs, es reaſons for concluding that this ſpecimen came from the d mine of Anglezark, near Chorley, in Lancaſhire, where it is ntifully found. He obſerves that this is the only mine in Engıd which is known to afford it. It has alſo been found in the nes of Strontain and Dunglaſs, near Dumbarton, in Scotland,

ſcarcely,

To obtain pure ponderous earth.

ſcarcely, if at all, ſoluble in water. The liver ſtone, or lapis hepaticus, contains about one third part of this earth. If ponderous ſpar be fuſed with about twice its weight of fixed alkali, its acid will unite with this laſt, and form a ſalt, which may be waſhed off b water, the ponderous earth remaining behind in combination with fixed air. This may be deprived of its fixed air by a ſtrong heat, which converts it into a ſtat perfectly reſembling quick-lime in taſte, and exhibiting ſimilar phenomena with water.

Native aerated ponderous earth.

The natural aërated ponderous earth differs fro that produced by art, in the circumſtance that it contains no water; and to this it ſeems to be owing th it does not loſe its fixed air by mere heat.

This earth differs from lime.

Though this earth reſembles lime in ſeveral reſpect yet its combinations differ from thoſe of the latte both in weight, and ſo many other reſpects, as ev dently ſhew that there is no reaſon to conſider the as one and the ſame ſubſtance. It is combinable wit acids.

Ponderous earth ſuppoſed to be metallic.

From ſeveral properties in which ponderous eart has been obſerved to reſemble metallic ſubſtances, has been ſuſpected to be of that claſs: but this ſuſp cion has not yet been verified by experiment.

Magneſia.

Moſt of the native ſpecimens of magneſian ear are remarkable for a certain ſoapy or greaſy feel. O theſe the moſt common are, ſteatites, of a greeniſh c lour, and ſoft enough to be ſcraped with the nail; ſo rock; lapis ollaris, or Spaniſh chalk, of a yellow whitiſh colour, but rarely black, rather harder th ſteatites, and ſo eaſily wrought and turned, that p are made of it. Aſbeſtos, amianthus, and the Venetian and Muſcovy talc, are included in this genus.

Epſom ſalt.

The combination of vitriolic acid and magneſia is very ſoluble in water, in which it remarkably differs from the combinations of the ſame acid with the calcareous or ponderous earths. This compound is known by the name of Epſom ſalt, and is found in ſome waters; but is moſt frequently obtained, for commercial purpoſes, from ſea water, after the common ſalt has been extracted by evaporation. If mild volatile alkali be added to a ſolution of Epſom ſalt, the alkali unites with the acid, and part of the earth falls to the bottom, combined with fixed air, which, when well waſhed, is mild magneſia.

Mild magneſia.

Pure magneſia.

Mild magneſia is a light impalpable powder, of a white colour; and forms a paſte with water, which has not much coheſion. Heat drives off its fixed air, and renders it ſomewhat harſher to the feel; but not cauſtic, nor ſoluble in water, like lime. Its taſte is very ſlight in either ſtate. The ſtrongeſt heat does not affect it, if pure. Acids diſſolve it, but alkalis ſcarcely affect it in the dry way.

Union of earths by fuſion.

As the various compounds of bodies uſually poſſeſs properties very different from thoſe of their principles, it is accordingly found that the earths, though infuſible alone, are not ſo when mixed together. The calcareous earth is found to be the ſolvent of other earths, for they are all rendered fuſible by a proper proportion of it. And theſe compounds of two earths will diſſolve ſtill more. So that though one hundred parts of lime will diſſolve very little ſiliceous earth; yet a compoſition of one hundred of lime with fifty of

magneſia,

magneſia, will diſſolve one hundred of ſiliceous earth; and this laſt compound will take up more magneſia than the mere calcareous earth could have done. Any three of the earths, in equal parts, will vitrify into a perfect glaſs, provided calcareous earth be one among them.

Suppoſed reduction of the earths.

It has lately been aſſerted, upon good authority, that the argillaceous, calcareous, ponderous, and magneſian earths were reduced to the metallic ſtate by ſtrongly heating them with charcoal[*]. But however it may be probable from analogy that ſuch reductions may be within the limits of poſſibility, it is at preſent generally underſtood that the metallic matter obtained in theſe experiments conſiſted of iron afforded by the crucibles made uſe of.

The new earths.

We ſhall frequently have occaſion to treat of the five ancient earths, as their various combinations preſent themſelves to our notice: but the three lately diſcovered earthy ſubſtances not having been ſubjected to experiments, except in the laboratories of the diſcoverers, will not again come under diſcuſſion in the preſent work. On this account therefore it will be proper to ſpeak rather more fully reſpecting them than the preceding, and likewiſe to enter more minutely into the deſcription of proceſſes than we might otherwiſe do in this early part of our work.

Characters of adamantine ſpar;

A ſtone has been within a few years brought from the Eaſt, which has received the name of Adamantine Spar. Two varieties are known[†]. The firſt

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[*] Journal de Phyſ. 1790.

[†] Extracts from the Memoir of M. Klaproth. Annales de Chimie, i. 183.

comes

—from China.

omes from China; it is cryſtallized in ſix-ſided priſms, vithout pyramids, varying in their length from half an ıch to one inch, and in breadth near one inch; its olour is grey, of different ſhades. Whole pieces are pake, but thinner fragments are tranſparent: its texure is ſparry, and it breaks with a poliſh. The ſparry exture produces a ſlight ſtriated appearance on its ſurace: its hardneſs is ſo great, that it not only cuts glaſs ike a diamond, but it marks rock cryſtal, and other ard ſtones: its ſpecific gravity is 3.710, and in ſome pecimens as high as 4.180. Small grains of magnetic alx of iron are ſometimes diſſeminated through this tone.

—from Bombay.

The ſecond variety is whiter, more decidedly ſpathoſe n its texture, and the grains of calx of iron are ſmaller, nd merely adhere to its ſurface. It is called corunlum at Bombay*. At Madras it is known by the ame of grinding ſpar.

Analyſis of adamantine ſpar.

M. Klaproth attempted the analyſis of this ſtone by eeping it in fuſion with fifteen times its weight of auſtic mineral alkali in a ſilver crucible for five hours; hen adding boiling water, filtering and ſaturating the lkali with an acid, which conſequently threw down hat portion of earth which had combined with the lkali. The undecompoſed part was repeatedly dieſted with concentrated boiling acids. The ſtone vas not completely decompoſed till after twelve repeitions of this proceſs; and it was found to conſiſt of wo parts clay, and one of an earth not ſoluble by uſion in alkalis, nor acted upon by acids. It differs

Peculiar earth.

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* Various ſpecimens have been found in France. See De orveau in the Annales de Chimie, i. 183.

there-

therefore from ſiliceous earth, as well as from the four other ſoluble earths.

Characters of the jargon of Ceylon.

The ſame chemiſt examined the jargon of Ceylon by proceſſes nearly ſimilar*. The colour of this ſtone is pale, of a yellowiſh green, inclining to red; forming upon the whole a kind of ſmoky grey tinge. Its regular figure is that of a four-ſided priſm, terminated by two obtuſe pyramids, compoſed each of four iſoſceles triangles. Its ſpecific gravity exceeds that of any other ſtone, being 4.615.

Pieces of this ſtone being ignited, thrown into water to render it leſs coherent, and then levigated upon porphyry, were fuſed in the ſilver crucible, with a large proportion of cauſtic fixed alkali. The ſolution was treated with water and with marine acid, which took up a ſmall part, and left a reſidue, which was again fuſed with alkali, and treated as before. After ſeveral repetitions of this proceſs, the whole was diſſolved. By ſaturating the acid with mild vegetable alkali, the earthy matter was thrown down. Digeſtion of part of this precipitate with marine, and part with vitriolic acids, indicated, after a due application of chemical methods, a conſiderable portion of ſiliceous earth, with a minute quantity of iron and nickel, and a much larger proportion of an earth which remained ſuſpended on account of its ſolubility in acids. This earth was found to differ in its properties from every other yet known: its ſolubility ſufficiently diſtinguiſhes it from ſilex. When precipitated by mild alkali, it did not become effervefcent, like lime or magneſia;

Peculiar earth.

neither

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* See the Memoir at length in the Journal de Phyſique for March 1790.

ither did it, like them, form ſelenite or Epſom ſalt ith vitriolic acid. It did not form alum with the riolic acid, as clay does. It differed eſſentially from onderous earth, in its not being precipitable by the ruſſian alkali; and in forming a ſalt with vitriolic id, which was exceedingly different from ponderous ar. This earth was not ſoluble either in microcoſmic lt, or in mineral alkali, when treated by the blow-ipe; but borax diſſolved it. The jargon was found contain in the hundred parts 31½ ſilex, ½ calx of on containing nickel, and 68 of this peculiar earth.

Mineral from New South Wales:

A mineral from New South Wales was put into e hands of Mr. Wedgwood by Sir J. Banks *. It onſiſted of a mixture of fine white ſand, a ſoft white arth, ſome colourleſs micaceous particles, and a few lack ones, reſembling black mica or black lead. Mr. Vedgwood made ſome experiments upon it, but does ot appear to have completely analyſed the maſs, moſt robably on account of its ſmall quantity.

—ſubjected to experiments.

Neither the nitrous nor vitriolic acids, concentrated r diluted, hot or cold, were found to take up any hing from this mineral which could be precipitated y alkalis; excepting that the ſtrong vitriolic acid, by ue management, indicated a minute portion of clay. ut the marine acid, by digeſtion near its boiling heat, cted on it with frequent exploſive burſts, and took p about one fifth of the whole. The crude mineral, ulverized and calcined, loſt its blackneſs, and one-ourth of its weight, but was found to be as difficult f ſolution as before. Water added to the marine

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[*] Wedgwood in the Philoſ. Tranſ. for 1790, page 306.

White earthy matter.

ſolution, threw down a white precipitate; and the ſeparation was ſo complete, that, after an addition of eight or nine times the whole bulk of water, there remained nothing in ſolution that alkali could precipitate. This white matter was inſoluble in water, and alſo in the nitrous or vitriolic acids, and in alkaline ſolutions. Strong marine acid took it up as before, by the aſſiſtance of the ſame degree of heat. A certain preciſe quantity of nitrous acid added to the marine ſolution, kept the white matter ſuſpended, even when diluted with water. Strong vitriolic acid did not throw down the white matter from the marine ſolution; but when the quantity added was nearly equal to that of the ſolution, part of the marine acid was extricated in white fumes, with effervefcence. The mixture, heated nearly to boiling, becomes tranſparent, and continues ſo in the cold. This ſolution is alſo precipitable by water, and the precipitate is ſoluble in marine acid.

Marine ſolution of the white matter:

The ſaturated marine ſolution does not cryſtallize by evaporation, but affords a deliqueſcent maſs, which is not corroſive, and parts with its acid in an heat near ignition. Pruſſian alkali does not precipitate the marine ſolution; but all the alkalis, whether mild or cauſtic, occaſioned copious precipitations, which were ſoluble in marine acid, and thence precipitable by water in the original ſtate.

—fuſibility.

This white precipitate is much more fuſible than any of the other ſimple earths. In a heat between 142 and 156 degrees of Wedgwood's thermometer, which is nearly as high as is produced in a ſmall air furnace, it melted in contact with clay, with flint, with chalk, with lime, with magneſia, with pure ponderous earth, and

with ponderous ſpar, in ſeveral different experi-
ts. In a hole ſcooped in chalk it run into a
oth whitiſh opake bead, not at all adherent to the
k itſelf; and in a cavity in charcoal it likewiſe
d, but did not ſeem to undergo any revivification.
of this was ſoluble in boiling marine acid, and
ipitable by water, as at firſt; but an accident pre-
ed the determination whether the whole was ſo-
e.

Peculiar earth.

appears proper therefore to conſider the white
ter as a new earth; directly ſoluble in no men-
um but marine acid, or perhaps its compounds;
cryſtallizable in this combination; precipitable by
er, and not by the Pruſſian alkali; parting with its
in a heat below ignition; and fuſible in a degree
heat not very much exceeding that required to
t caſt iron.

Other parts of the mineral.

he black ſubſtance which ſeems to have compoſed
ut one-fifth part of the crude mineral, was found
eſemble plumbago in its leading properties, but
reſidue did not appear to be iron. The remaining
e fifths of the mineral which reſiſted the humid
cks in Mr. Wedgwood's experiments, was probably
; but he does not ſpeak of any direct examination
ts properties by fuſion with alkalis, the ſparry acid,
therwiſe.

CHAP. V.

OF THE SIMPLER SALTS; NAMELY, ALKALIS AND ACIDS.

ALKALIS.

Characters.

THE alkalis are three in number; the vegetable the mineral, and the volatile alkali. Of theſ the two former are diſtinguiſhed by the general appellation of fixed alkalis. The general properties o fixed alkalis are—1. They change the blue ſyrup violets to a green. 2. Their taſte is peculiar, and di agreeably cauſtic, even when diluted with wate 3. They have a ſtrong attraction for water, wi which they unite in all proportions, and even attra it in ſufficient quantities from the atmoſphere to b come fluid. 4. They combine with acids by a ſtrong affinity than is poſſeſſed by moſt other ſubſtances, at moderate temperature. 5. Moſt inflammable ſu ſtances are acted upon by them. 6. They melt in moderate heat, and in a ſtronger heat they are vol tilized. 7. In the dry way they diſſolve earths, an the calces of metals.

Vegetable fixed alkali.

The vegetable fixed alkali is found in ſome ſa which may be ſaid to be of the mineral kingdom; b it is obtained for all the purpoſes of trade and ſcien from vegetable matters. Of this there are ſeve kinds, which differ only in the reſpective quantit and nature of the impurities they contain. The ce dres gravelées is a ſtrong alkali, made by burning t huſks of grapes and wine-lees. Potaſh is procur fr

ALKALIS.

Methods of procuring the vegetable alkali.

om wood-aſhes, and is very far from being pure.
oſt vegetables afford this alkali by burning them,
d mixing their aſhes with pure water; which, after
cantation or filtering, may be evaporated, and will
ave the ſalt behind. The pureſt is obtained by
rapping tartar in wetted brown paper, and placing
e parcels in beds or ſtrata alternately with charcoal
a furnace. The whole is then to be ſet on fire,
d the fire continued till the blackening ſmoke ceaſes
riſe. If the heat be too intenſe, the alkali will
elt, and mix with the impurities of the coal; but
hen the proceſs is well conducted, the parcels may
taken out entire. By lixiviation or ſolution in pure
ater, with ſubſequent filtration, evaporation, drying,
d calcining in a low heat, the alkali is obtained very
hite, and contains a conſiderable portion of fixed air.
his might be driven off by heat; but it is not neceſ-
ry to be done in that way, as it would be attended
th ſome danger of the ſalt corroding the veſſel, and
coming leſs pure. The vegetable alkali is known in
e ſhops by the name of ſalt of tartar; but moſt
emiſts in London ſell the impure alkali of potaſh by
is name.

Purifying of alkalis.

It is not eaſy to purify the common vegetable alka-
met with in trade, and it is ſeldom attempted. The
emiſt is not under any neceſſity to employ his time
procuring the alkalis abſolutely diſengaged from all
her matter, as they will be equally uſeful if kept in
mbination either with fixed air or with water;
which ſtates the quantities may be more accu-
tely aſcertained by weight when uſed, than if
re; becauſe their rapid attraction for water, in

the latter caſe, renders the weighing almoſt impracticable.

Alkalis which contain fixed air, are called mild alkalis.

Alkali of nitre, called fixed nitre.

For very nice purpoſes this alkali may be had from common nitre by deflagration. Nitre conſiſts of the alkali united with an acid. If the fineſt priſmatic nitre be fuſed, and made red-hot in a crucible, and charcoal be then added by degrees, a moſt intenſe combuſtion takes place, during which the acid principle of the ſalt is diſſipated, and the alkali is left in combination only with fixed air. More charcoal muſt be added, as long as it continues to produce the vivi flame; and the heat muſt be raiſed towards the end in order that the decompoſition of the laſt portions o the nitre may be more completely effected. This ſal has been improperly called fixed nitre; but there is n difference between the pure ſpecimens of this alkal whatever ſubject it may have been originally obtaine from.

Purification of fixed alkali.

Fixed alkalis may be had in a ſtate of great purit by treatment with ardent ſpirit*. The alkali is fir to be deprived of moſt of its fixed air by boiling, wit about its own weight of quicklime, in twelve parts o water; and the clear ſolution muſt then be evaporate till it begins to be ſlightly conſiſtent. It muſt then b mixed with the ſtrongeſt ardent ſpirit; and part o the ſpirit may be drawn off by diſtillation. As ſoo as the retort has become cold, it is found to contain ſolution of pure alkali in ardent ſpirit, which floa ove another aqueous fluid, containing that part of e alkali in cryſtals which ſtill retains its fixed air, d alſo the earthy or metallic impurities of the kali. The ſpirituous ſolution being decanted off, d evaporated on a ſand bath, affords cryſtals of pure kali in groups of quadrangular pyramids, which are ry deliqueſcent, and ſoluble both in water and ardent irit, with the production of cold.

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* Berthollet, in the Journal de Phyſique for 1786.

Oil of tartar.

The vegetable alkali, in its uſual ſtate, deliqueſces the air, and conſequently unites with water in all oportions. The ſtrong ſolution of this alkali is ually called oil of tartar per deliquium. Its action n the ſkin produces a ſenſation or feel of greaſineſs, hich has given occaſion to this appellation. But it ay be had in permanent cryſtals, if enough of fixed r be added to its ſolution.

Mineral alkali.

The mineral alkali in its obvious properties differs ut little from the vegetable. Its attractions in genel are leſs ſtrong, and the compounds it forms with her bodies are very different from thoſe produced th the vegetable alkali. It uſually contains enough fixed air to render it much leſs attractive of water an ſalt of tartar. If the quantity of water containing t of ſoda be diminiſhed to about two and a half times e weight of the ſalt; this laſt begins to ſeparate in yſtals, which do not deliqueſce in the air, but become y, and fall to powder, by the loſs of that portion of ater which entered into the formation of the cryſtals.

Water of cryſtallization.

Efflorescence.

The water which enters into the formation of the yſtals of any ſalt, is called the water of cryſtalliza- on; and ſuch ſalts as fall to powder by expoſure to the air, are ſaid to effloreſce; the pulverulent ſubſtance thus obtained is ſometimes called an effloreſcence.

Abundance of mineral alkali; in ſea ſalt.

Mineral alkali abounds in vaſt quantities in the waters of the ſea, where it forms half the weight of the common ſalt; and it is ſometimes found in other natural combinations. The effloreſcence, or ſaline matter, which hangs upon old damp walls, conſiſts of this ſalt united to fixed air and water; and in many places in Aſia and Africa it is collected at the ſurface of the earth.

—obtained by incineration.

Turner's proceſs with common ſalt.

The mineral alkali in trade is obtained by burning certain plants which grow on the ſea ſhore. It contains ſeveral neutral ſalts in ſmall proportions, which may be ſeparated by cryſtallization; as the alkali, being the moſt ſoluble, remains ſuſpended in water longe than the reſt. Sea ſalt may be decompoſed, an its alkali obtained alone, but not ſufficiently cheap fo common uſes. Mr. Turner's proceſs is ſaid* to conſiſt in mixing a quantity of litharge (or calcine lead) with half its weight of common ſalt; which, afte trituration with water till it aſſumes a white colour, i left to ſtand ſome hours: after which a decompoſitio enſues, the alkali becoming diſengaged with water while the acid unites with the metallic calx. This laſt by a proper degree of heat, produces a fine greeni yellow pigment, the ſale of which is the chief objec of the manufacturer.

The fixed alkalis are ſtill conſidered as ſimple ſubſtances with regard to the preſent ſtate of our knowledge. It is ſuſpected however that the fixed veget

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* Cronſtedt's Mineralogy, by Magellan, Vol. I. p. 336.

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alkali may conſiſt of lime in combination with the
ſtance called phlogiſticated air; and that the mineral
ali is compoſed of magneſia, united to the ſame
ſtance. The reaſons for theſe ſuppoſitions are:—
A ſmall quantity of common nitre is produced by
poſing waſhed chalk for ſome months to the exhala-
ns of putrid animal ſubſtances. The repeated diſtil-
ion of ſoap affords volatile alkali, and this contains
logiſticated air. And a portion of magneſia has
en obtained by repeated ſolutions and calcinations
mineral alkali.

Cauſtic ſolution of alkali:

Fixed alkalis, deprived of the fixed air they may
ntain, by boiling them for a ſhort time with quick-
ne, which has a ſtronger attraction to the air, and
comes converted into chalk by the proceſs, are then
id to be cauſtic, becauſe they act with ſuch energy
to corrode and deſtroy animal ſubſtances. Soap
es is a ſolution of this kind; and the combination of
cauſtic alkali with fat, or oil, is well known by the
me of ſoap. If one part of lime, and two of ſalt
ſoda, be boiled in twelve parts of water for a ſhort
ne, and the filtered lixivium be evaporated till its
ecific gravity be about 1.375, or, which is the ſame
ing, till a phial which would contain an ounce of
ater would contain an ounce and three eighths of the
lution; the ſoap may be made by mere mixture of
is lye with olive oil, in the proportion of one part of
e former with two of the latter, in a glaſs or ſtone
are veſſel. This mixture, being beat up from time to
me with a wooden ſpatula, ſoon becomes conſiſtent;

—or ſoap lees.

Soap.

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* Thouvenel on Nitre. Chaptal's Elements of Chemiſtry, I. 51. Eng. tranſl. and the authors by him cited.

and in ſeven or eight days it forms a very white and hard ſoap.

Manufacture of ſoap in the large way.

In large manufactories the lye is made no ſtronger than to float an egg, when the workmen begin to form the mixture. To a part of the lye diluted they add an equal quantity of oil, which is ſet on a gentle fire, and agitated. When the combination begins to take place, the reſt of the lye is added, and the whole digeſted by a gentle heat till the ſoap is formed. If well made, it is firm and white, and completely mixes with water, without exhibiting any greaſe on the ſurface. Trials are made of it during the boiling; and the requiſite additions, either of oil or alkali, are made as circumſtances require.

Manufacture of glaſs.

That beautiful product of human induſtry, glaſs, conſiſts of ſiliceous earth diſſolved in an alkali. For this purpoſe, nothing more is neceſſary than to expoſe a proper mixture of ſand, flint, or cryſtal, and fixed alkali, to heat in a furnace till they are incorporated together by fuſion. Simple however as this proceſs may appear, it is by no means an eaſy operation to make a perfect glaſs. If the materials be impure, and contain either metallic particles, or ſuch as cannot be vitrified, the glaſs will be coloured, or defaced with opake ſpecks. If the proportion of alkali exceed two parts to one of earth, the glaſs will be liable to alteration by the action of the air or ſaline ſubſtances, eſpecially acids. If the fuſion be not continued a ſufficient time, the glaſs will be imperfect for want of a ſufficient combination of the materials: and no means have yet been found to prevent the lower part of the pots of glaſs from containing a denſer glaſs than the

Difficulties.

upper

pper, by the ſubſidence of the heavier materials; circumſtance which produces the appearance of ıreads or veins in the work, on account of the dif- rent action of the ſeveral parts of the ſame glaſs on ıe rays of light. The management of the heat is ſo a material point; for every increaſe of heat extri- ıtes bubbles of ſome elaſtic ſubſtance; and if the glaſs ufed during this effervefcence, it will abound with :tle cavities which injure its tranſparency. The im- erfections of glaſs are moſt ſenſibly felt in the con- ruction of optical inſtruments, eſpecially thoſe which re called achromatic.

Frit.

To prevent the ſwelling, at the firſt combination of ıe materials, they are previouſly mixed, and expoſed r a conſiderable time in a lower heat than is ſuffi- ient to convert them into glaſs; by which manage- ıent great part of the more volatile matters are diſſi- ated. This imperfect combination is called frit, and afterwards fuſed by a ſtronger heat. Glaſs utenſils, nleſs very ſmall, require to be gradually cooled in an ven. This operation is called annealing; and is ne- eſſary to prevent their cracking by change of tem- erature, wiping, or ſlight accidental ſcratches.

Manufacture of ſal ammoniac.

The volatile alkali is moſt commonly obtained rom ſal ammoniac. This ſalt was formerly imported rom Egypt, where it is procured by ſublimation from oot produced by burning the dung of camels. It is ıow made in great plenty for the purpoſes of trade n Great-Britain. The component parts are volatile lkali, and the ſame acid as enters into the compoſi- ion of ſea ſalt, and is called the marine acid. The olatile alkali is obtained in an impure liquid ſtate by by the manufacturers, who diſtil it from bones, or ſoot, or any other ſubſtance that affords it. To this they add the vitriolic acid, and alſo common ſalt, in due quantities. The vitriolic acid firſt combines with the volatile alkali; but when the common ſalt, which conſiſts of fixed mineral alkali and marine acid, is added, a change of the principles takes place by double elective attraction. The vitriolic acid ſeizes the mineral alkali, and forms the new compound known by the name of Glauber's ſalt; while the marine acid unites with the volatile alkali, and forms ſal ammoniac. By evaporation of the water, theſe ſalts are ſeparated by cryſtallization, and the ſal ammoniac is ſublimed into cakes for ſale.

Volatile alkali:

In order to diſengage the volatile alkali from ſal ammoniac by diſtillation, it is neceſſary to add ſome fixed ſubſtance which ſhall combine with and prevent the marine acid from riſing. Chalk and ſlaked lime are the bodies commonly uſed. If a mixture of two parts of chalk, and one of ſal ammoniac in powder, be expoſed to a ſand heat in a retort, with a receiver adapted, a change of principles by double affinity takes place. The chalk, which conſiſts of lime and fixed air, is decompoſed, and alſo the ſal ammoniac. The lime unites with the marine acid, and forms a fixed earthy ſalt, which remains in the retort; and the fixed air unites with the volatile alkali, and paſſes into the receiver, where it appears in the form of a white hard ſalt of a pungent ſmell. This is the mild volatile alkali, or ſal volatile of the apothecaries and perfumers. It is well known as a ſtimulant uſually put into ſmelling bottles.

—obtained by the medium of chalk:

Whe

ALKALIS.

—obtained by the medium of lime.

When lime, or calcareous earth deprived of fixed
, is made uſe of, the decompoſition takes place as
ſore; but the volatile product has a very different
pearance. It conſiſts, for the moſt part, of a perma-
ntly elaſtic or aërial fluid, which very readily com-
ies with water, but may be confined in its elaſtic
te in veſſels over mercury. Moſt of this product
is formerly loſt, becauſe no more of it was detained
the veſſels than had combined with the water which
is driven over by heat from the materials in the re-
rt. But by the uſe of an apparatus upon the prin-
ple of fig. 21, the air may be received and abſorbed
water, without that great loſs which muſt have
iſen from the aërial fluid riſing long before the wa-
r, and the quantity of this laſt being inſufficient to
tain it.

Alkaline air.

This permanently elaſtic fluid is called alkaline air,
id conſiſts of the pure volatile alkali itſelf. If fixed
r be added to it, a white cloud is formed, conſiſting
mild volatile alkali, which precipitates; and the
rs are either diminiſhed or diſappear, according to
eir relative proportions to ſaturate each other, or
ieir reſpective degrees of purity. With the marine
id air, hereafter to be treated of, which is the pure
arine acid, it forms ſal ammoniac in the ſame
ianner. It unites with equal readineſs with the other
id airs. With water it forms the fluid volatile
lkali commonly called ſpirit of ſal ammoniac with
me.

Decompoſition and formation of volatile alkali.

The volatile alkali is decompoſed and formed again
n many chemical proceſſes. Theſe, generally ſpeak-
g, require a more intimate knowledge of chemical

facts

ALKALIS.

facts than the reader can yet be ſuppoſed to poſſeſs, for them to be ſpoken of at length in this place. It will therefore be ſufficient to obſerve, that the dimenſions of alkaline air are greatly enlarged by repeatedly paſſing the electric ſpark or exploſion [*] through it, or by igniting a piece of earthen-ware in it; and it is by this means rendered incapable of being abſorbed by water, and becomes inflammable. By the admiſſion of vital air, and detonation, the inflammable part is condenſed, and the remainder is found to be phlogiſticated air [†]. Hence, as well as from other experiments, it is concluded that alkaline air conſiſts of four parts by weight of phlogiſticated, and one of inflammable air.

Characters of acids.

Acids are a genus of ſalts, which may be conſidered as leſs ſimple than the fixed alkalis; becauſe there are experiments which clearly ſhew that they may be decompoſed into principles ſtill ſimpler. Their properties are—1. They change the blue vegetable colours of ſyrup of violets, or tincture of litmus, to a red. 2. Their taſte is ſour, and in general corroſive, unleſs diluted. 3. Moſt of them unite with water in all proportions; and many have ſo ſtrong an attraction for it, that they cannot be exhibited in the ſolid ſtate. 4. They combine with alkalis by a ſtronger affinity than is poſſeſſed by moſt other ſubſtances to thoſe ſalts at a moderate temperature. 6. They act upon earths, and upon moſt inflammable ſubſtances and metals.

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[*] Prieſtley, II. 239. V. 218. VI. 189.

[†] Berthollet in Mem. Acad. Par. for 1785, page 324. Alſ Auſtin in Phil. Tranſ. Vol. LXXVIII. p. 387.

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Enumeration.
Mineral acids.

The acids found in the mineral kingdom are—the
riolic acid, known in commerce by the name of oil
vitriol; the nitrous acid, called ſpirit of nitre; the
rine acid, called ſpirit of ſalt; the aërial acid, or
ed air; the acid of borax, called ſedative ſalt;
acid of ſpar, or ſparry acid; ſuccinous acid, or
d of amber; the acid of phoſphorus, or phoſpho-
acid; the acid of tin; the acid of arſenic; the
d of molybdena; the acid of tungſten, or of
lfram.

Vegetable acids.

The vegetable kingdom affords the acids of lemons;
apples, or unripe fruits; of galls; of benzoin; of
rtar; of ſugar, or ſorrel; the empyreumatic acid of
rtar; the empyreumatic acid of ſugar, or mucilage;
e empyreumatic acid of wood; the acid of cam-
or; the acid of cork; and the acetous acid, or
negar.

Animal acids.

The animal kingdom affords the acid of milk; the
id of ſugar of milk; the acid of ants; the acid of
uſſian blue; the acid of fat; the acid of the ſtone
the bladder; and the acid of ſilkworms.

Inflammable additions to acids.

When an inflammable ſubſtance is added to a ſtrong
id, the effects in general are, that the acid is ren-
red more volatile, and part flies off in an elaſtic
rm, which has various properties, according to the
ature and properties of the acid, as will be hereafter
ewn.

Theory.

In the theory of phlogiſton, acids are ſuppoſed to
ontain that principle, and to be capable of uniting
ith it in various proportions. When they have re-
eived a larger proportion, they are rendered more
olatile, and fly off in the elaſtic form; and when
they

Theory.

they have a leſs than the uſual proportion of it, they are ſaid to be dephlogiſticated, and act mor ſtrongly on phlogiſtic bodies. In the new theory, acids are ſuppoſed to conſiſt each of a peculiar baſ united to vital air in a fixed ſtate. If they act on combuſtible body, and become deprived of part of thei vital air by its action, their conſtitution is changed and their baſe is more diſpoſed to fly off; but if b any means they obtain an over-proportion of vita air, their action on combuſtible bodies is more effica cious.

Vital air a component part of acids.

Moſt of the phlogiſtian chemiſts admit of the exiſt ence of vital air, as a component part of acids; a poſi tion which ſeems indeed to be as well eſtabliſhed upo facts as any part of the ſcience of chemiſtry.

Neutral ſalts.

Combinations of alkalis with acids are called neutr ſalts.

CHA

CHAP. IX.

OF METALLIC BODIES IN GENERAL.

CHARACTERS OF METALS.

Entire metals.

Perfect and imperfect metals;

Calces.

METALLIC ſubſtances are very eaſily diſtinguiſhable from all other bodies in nature, by eir very great weight, and that opake ſhining ap- arance which is called the metallic ſplendour or illiancy. Very few ſubſtances have half the ſpecific avity of the lighteſt among the metals. They are l fuſible, though at very different temperatures; and the fuſion be made in cloſe veſſels, they fix again by ld, without having ſuffered any change but that of ternal figure, which muſt be produced in all bodies hich have been either liquefied or volatilized; namely, ey aſſume the form of the veſſel which contains them. me of them may be extended conſiderably by the mmer, without breaking them. This property is lled malleability; and the metallic bodies which poſſeſs are called entire metals, or metals, in contradiſtinction ſuch as are more brittle, and are called ſemi-metals. etallic ſubſtances are alſo called perfect and imper- ct. The perfect are ſuch as undergo no laſting change their properties by any heat we can apply to them, leaſt in common furnaces. The imperfect metals, hen expoſed to a ſtrong heat, with acceſs of vital ir, are changed, by a proceſs ſimilar to burning, and in me of them with an actual flame, into a brittle dull bſtance called a calx, which is heavier than the etal it came from, though its ſpecific gravity is not

Acids.

ſo great. Some are even converted into acids. If the calx of a metal be expoſed to ſtrong heat in a cloſed veſſel, with ſome inflammable matter, it recovers its metallic ſtate. This is called reduction or reviving of the metal.

Enumeration of metals.

All metals are imperfect except gold, ſilver, and platina. The imperfect metals are, mercury, lead, copper, iron, and tin; and the ſemi-metals are, biſmuth, nickel, arſenic, cobalt, zinc, antimony, manganeſe, wolfram, molybdena, and uranite. The names arſenic, antimony, manganeſe, wolfram, and molybdena, being uſed to denote the mineral ſubſtance from which the ſemi-metals are obtained, the ſemi-metals themſelves are diſtinguiſhed by the name of regulus of arſenic, regulus of antimony, and ſo forth; though modern chemiſts often uſe the ſimple term to denote the ſemi-metal itſelf alone.

Regulus.

Freezing point of metals.

Metals, like other fuſible bodies, have each a fixed temperature, or freezing point, at which they become ſolid. They aſſume a cryſtallized figure in cooling, which is different in each, and may be ſeen by fuſing them in melting pots with a hole in the bottom, ſtopped with a ſtopper; for in this caſe, if the ſurface be ſuffered to congeal, and the fluid metal beneath be ſuffered to run out through the hole, the under ſurface of the remaining metal will be curiouſly cryſtallized. The ſpecific gravity of metallic ſubſtances is very conſiderably affected by the gradual or haſty cooling, or tranſition from the fluid to the ſolid ſtate. Hammering renders them harder and more elaſtic; but this effect is deſtroyed by ignition.

Cryſtallization.

Affinities.

The affinities of metals to each other are various. Some

METALLIC SUBSTANCES.

ne will not unite at all; others mix very readily,
even combine together. On this property is
ded the art of ſoldering; which conſiſts in joining
pieces of metal together by heating them, with a
piece or plate of a more fuſible metal interpoſed
veen them. Thus tin is a ſolder for lead; braſs,
, or ſilver, are ſolders for iron, &c.

Solders.

Iountainous diſtricts, where the ſurface of the
e has been thrown up or diſturbed, in remote
, by earthquakes, volcanos, or other great convul-
s of nature, are the moſt abundant in metallic
ies. In digging into the bowels of the earth, the
ious materials are moſtly found diſpoſed in ſtrata
beds, which in plains lie level, but in mountains
inclined; whence it happens that in mountainous
ntries ſome ſtrata are often expoſed to the day,
ich would elſe have been too deeply lodged to be
ne at by human art. It is in the ſtratified moun-
s that metals are uſually found, moſtly in a ſtate
ombination either with ſulphur or arſenic, or in the
e of a calx. They are alſo found, though leſs fre-
ntly, in the metallic or native ſtate.

Countries moſt abundant with metals.

The combinations, or earthy bodies, which contain
tals in ſufficient quantity to be worth extracting, are
ed ores. Iron ore ſometimes forms entire moun-
s; but in general the metallic part of a mountain
very inconſiderable in proportion to the whole. The
s run either parallel to the ſtony ſtrata, though far
m having the ſame regularity of thickneſs, or they
ſs the ſtrata in all directions. Theſe metallic ſtrata
called veins. The cavity formed by art in the earth,
the extraction of metals or any other mineral bo-

Ores. Veins. Mines. Matrix.

K dies,

dies, is called a mine. The ſtone wherein a metall ore is uſually bedded, is called its matrix. Theſe a not peculiarly appropriated to any metal, though ſom ſtones more frequently accompany metals than other

Operations for extracting metals from ores.

The general operations by which metals are o tained from ores are—1. The minerals are ſelected; a ſuch only are taken as from experience are known, the external figure or appearance, to contain met 2. They are reduced to powder; and the lighter par waſhed away, by means of water, in a ſhallow troug 3. The volatile parts are diſſipated by the operati called roaſting. 4. The ores are ſmelted by thro ing them into the midſt of the fuel of a furnace, wi earthy ſubſtances which are diſpoſed to run into gla In this operation, the glaſſy matter, called ſcoria, ſome meaſure produces the effect of rendering t lower part of the furnace a cloſed veſſel; and the fu revives the metal, which in the ore is uſually of t nature of calx. The revived metal being much denſ than the ſcoria, falls to the bottom, and is ſuffered run out by proper openings. Theſe are the gener operations, but they are not all neceſſary in all caſe and the particular practice with the ſeveral ores each metal, muſt vary according to the properties the metal itſelf, and the different ſubſtances it united with.

Aſſaying, or eſſaying.

The extraction of metals from ores, in the ſm way, which is neceſſary to be made in order to aſce tain whether the ſpecimens are worth working, called aſſaying or eſſaying. In theſe ſmall trials t fuſibility of the pounded ore is increaſed by an add tion of black flux, which is an impure alkali, form mixing two parts of tartar with one of nitre, and ting them on fire. Metallic ores may be very accu- ely aſſayed by ſolution and precipitation in the hu- d way.

Humid way.

Theory.

The theory of the calcination and reduction of me- s, according to the ſyſtem of phlogiſton, is as fol- ws :—Metals, like all other inflammable bodies, con- n phlogiſton united to a baſe. While the vital part the air unites with the baſe, the phlogiſton is diſen- ged, and leaves behind it the combination called a lx, which is heavier than the metal, becauſe the air ceived exceeds the weight of the phlogiſton diſen- ged.—In the antiphlogiſtic ſyſtem, metals are con- dered as ſimple ſubſtances, which are converted into lces by their union with vital air, and are revived by eating them with any other matter which is more ombuſtible than themſelves; that is to ſay, which as a ſtronger attraction for vital air, at the tempera- ure of reduction. Some of the maintainers of phlo- iſton admit that the vital air unites with that principle f inflammability, and compoſes a ſubſtance which ombines with the baſe of the metal. Here the fact grees with the ſtatement of the antiphlogiſtians, but ne explanation is leſs ſimple.

Mixture of metals.

Moſt metals will uniformly mix with each other; and he ſpecific gravity of the compound is ſeldom ſuch as would have been deduced from the ſuppoſition of a mere mixture, or ſimple appoſition of parts. Their fuſibility is likewiſe greatly changed by mixture, and according to no certain rule yet diſcovered.

Alloys.

Mixtures of metals are frequently called alloys. But the word alloy, or allay, is moſtly uſed to denote a portion of metal which is added to the precious metals, gold or ſilver.

Solubility of metals in acids.

Metals are moſtly ſoluble in acids, with which they form ſalts. When a metal is added to an acid, the general effect produced is the ſame as would have ariſen from the addition of any other combuſtible ſubſtance to the acid. If an alkali or earth be added to a metallic ſolution, the metal falls to the bottom in the form of a calx. But if a metal which has a ſtronger affinity with the acid than the metal already diſſolved has, be added to ſuch a ſolution, the former metal will fall to the bottom in its metallic ſtate, and the latter will be diſſolved without cauſing any of the eſcape of elaſtic fluid, and other appearances, which would have taken place if it had been applied to the mere acid; notwithſtanding which, the latter metal, if precipitated by an incombuſtible ſubſtance, ſuch as an alkali or earth, will be in the ſtate of a calx.

Precipitation.

Inferences.

It is evident, from theſe facts, that the action of acids upon metals is ſimilar to that of heat with acceſs of vital air; and of courſe may be accounted for, upon both the theories of chemiſtry, in the ſame manner as combuſtion itſelf. According to the original theory, when an acid acts upon a metal, it unites with the baſe of the metal, and expels the phlogiſton; which either riſes alone, in the form of inflammable air; or, combining with the acid itſelf, forms an acid air, or volatile acid. If an alkali be added, the calx falls down, combined with air, which it obtains either from the alkali or the acid; but if a metal be added, the phlogiſton of this laſt, uniting with the calx of the former, revives it, and it falls down in its metallic ſtate. The new theory

New theory.

ry may be applied as follows: When a metal is ed to an acid, it attracts vital air either from the itſelf or from the water. If the former, the acid f is decompoſed; and its baſe, combined with an er proportion of vital air, ariſes in the form of tile acid, or acid air. But, if the latter, the water f is decompoſed, its vital air combining with the al, and its inflammable air flying off: in this caſe, acid is ſuppoſed to do nothing more than hold calx in ſolution, and by that means facilitate the on of the water, which would be much leſs effec- if the calx were ſuffered, on account of its in- bility, to remain upon and defend the ſurface of metal; which, by reaſon of its inſolubility in e water, it would not fail to do, if the acid were preſent.

Precipitation of metals by metals.

letals are precipitated by each other in the ſame er, or nearly ſo, in all acids. Hence it is inferred, this effect is produced by the reaction of ſome mon principle, either of the metal or of the acids. he old theory, a metal which has a ſtronger at- tion for phlogiſton, will take that principle from ther metal which holds it more weakly; and of rſe the latter will cauſe the former to be precipi- d in its metallic form. In the new theory, a con- y tranſition of vital air from the acid produces the e effect: for if a metal has a ſtronger attraction vital air than is exerted by another metal already in ition, it will deprive this laſt of it, and cauſe it to down in the metallic ſtate.

Limit of ſolution in acids.

Acids diſſolve metals only in their calciform ſtate; l there is a certain limit near which the ſolution is beſt performed. If an acid be of ſuch a nature as to be incapable of calcining a metal, it will not diſſolve it, though the ſame acid would diſſolve the calx if preſented to it; and if the calcination be carried on too far, the calx will likewiſe be inſoluble. To explain this according to the two theories, it may be obſerved, that acids calcine metals by virtue of their attraction for phlogiſton, and ſuſpend the calx by virtue of the ſame power exerted on the remaining portion of phlogiſton, of which they cannot in general diveſt the calx; conſequently, if the calx be diveſted of this portion, i will be inſoluble. Or, in the other theory, the ſimpl metal attracts as much vital air from the acid as i ſufficient to convert itſelf into a calx, but not enough t ſaturate it with that principle: it is therefore ſuſpended in conſequence of its remaining weak attraction fo the vital air of the acid. But if the calcination b complete, that is to ſay, if the affinity of the metal fo vital air be perfectly ſatisfied, the remaining attractio of the metal for vital air will ceaſe, and it will b inſoluble.

Theory of ſolution.

Action of various ſubſtances on metals.

The direct action of alkaline ſalts upon metals i not conſiderable: ſulphur combines with moſt o them readily in the way of fuſion; and the combinatio of ſulphur with an alkali, called liver of ſulphur, is powerful ſolvent of all metals except zinc. Nitr heated with metals, acts in the ſame manner as it do with other inflammable bodies—it deflagrates, an the metals become calcined. The perfect metals r ſiſt the action of nitre.

BOO

BOOK II.

RTICULAR CHEMISTRY.

SECTION II.

CERNING THE MINERAL ACIDS, AND THER MINERAL BODIES WHICH ARE CONVERTIBLE INTO ACIDS.

CHAP. I.

ULPHUR, VITRIOLIC ACID, AND THE COMBINATIONS THEY FORM WITH OTHER BODIES.

SULPHUR.

LPHUR, or brimſtone, is a well-known hard, rittle, inflammable ſubſtance, of an opake yellow r. It is found more or leſs pure in the neigh- ood of volcanos, where moſt probably it is al- expelled from ſome previous ſtate of combina- by the heat of ſubterraneous fires. It is a very non ingredient in a great variety of minerals and ; but it is extracted for ſale chiefly from a ſtone d pyrites. This ſtone is often of an irregular lar figure; and, when broken, is found to have a ted texture, the fibres uſually converging towards tre, Their great weight, and the ſhining golden

Pyrites.

SULPHUR.
Pyrites.

colour of ſome ſpecimens, often lead the ignorant to ſuppoſe them rich in precious metal. The contents of the pyrites are various; but the kind here ſpoken of contains from one ſixth to one third of its weight of ſulphur, one eighth to five eighths iron in a calcined ſtate, and the reſt clay and ſiliceous earth. They give fire plentifully with the ſteel; whence their name is derived.

Diſtillation of ſulphur:

A moderate heat will expel the ſulphur from pyrites, as it is conſiderably volatile. In the large way, in Germany and Italy, the pyrites are put int earthen cucurbits, diſpoſed in a furnace in ſuch manner that when the ſulphureous part melts, it run into veſſels filled with water, and there congeals.

—ſublimation.

Sublimation is neceſſary to deprive ſulphur of th accidental impurities it may contain. This may b done in an earthen cucurbit ſet on a ſand bath, wit a head properly adapted. The ſulphur riſes by a ver gentle heat, little more than is ſufficient to melt it and the fine ſublimate thus obtained is called flowers brimſtone.

Action of water upon ſulphur.

Water has no immediate action on ſulphur. It ſaid, however, to ſoften the outſide by long conta with it; and if ſulphur be heated nearly to ſuch degree as to ſet it on fire, and then poured into wat it becomes ſoft, and partly tranſparent. In proceſs time it recovers its original hardneſs and opacity. ſteam of water be paſſed over ſulphur contained i heated earthen tube, inflammable air is extricated ther from the ſulphur or the water, and comes out the end of the tube*. The experiment is troub ſome on account of the ſulphur ſubliming.

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* Prieſtley, VI. 150.

SULPHUR.

The combinations of ſulphur with earths or alkalis are called hepars, or livers of ſulphur, from their colour. There is no perceptible action between ſulphur and ſiliceous earth. Argillaceous earth has very little action upon it in the direct way; but lime unites readily with it. If freſh quick-lime and flowers of ſulphur be mixed, and water be added a little at a time, the heat of the lime will be ſufficient to produce the combination. On addition of more water, it becomes reddiſh, and emits a fetid ſmell of rotten eggs, which is common to all the hepars. The more cauſtic the lime, the deeper the colour of the hepar. The pure fixed alkalis decompoſe calcareous hepar, by virtue of their ſtronger affinity to the ſulphur: and any acid whatever decompoſes it, by attracting the lime; the ſulphur at the ſame time falling to the bottom in the form of a ſubtle powder, formerly called magiſtery of ſulphur.

Combination of ſulphur; with lime:

Pure ponderous earth boiled in water with ſulphur, has but little action upon it: but in the dry way, when ponderous ſpar, or the combination of vitriolic acid and ponderous earth, is ſtrongly heated in a crucible with charcoal, a coherent maſs is formed, which is ſoluble in water, with the ſmell and other hepatic characters; and if any acid be added which will form a ſoluble ſalt with the ponderous earth, a precipitate of ſulphur will be obtained.

—with ponderous earth:

If a ſmall quantity of magneſia, and an equal quantity of flowers of ſulphur, be incloſed in a veſſel perfectly filled up with diſtilled water, and well ſtopped, and then expoſed to heat by immerſion in boiling water for ſeveral hours, a combination will take place, and

—with magneſia.

SULPHUR.

and the water will contain a magneſian liver of ſulphur; from which the earth may be precipitated by the addition of an alkali, which will unite with the ſulphur; or the ſulphur may be precipitated by an acid, which will combine with the earth.

Combination of ſulphur with fixed alkalis.

The fixed alkalis combine very readily with ſulphur, either in the moiſt or dry way, whether they be in a pure or cauſtic ſtate, or combined with fixed air; though more ſtrongly in the former than the latter caſe. If a ſolution of fixed alkali in water be boiled with half its weight of powdered ſulphur, a combination takes place, and liver of ſulphur is formed. Or, if equal parts of dry alkali and powdered ſulphur be melted in a crucible, and poured out on a flat poliſhed ſtone, as ſoon as the fuſion is complete, the combination will be of a liver colour, and is the ſolid hepar. If it be made with a pure or cauſtic alkali, its colour is deeper, and its characteriſtic properties more intenſe, than when a mild alkali is uſed. A ſolution of the ſolid hepar in water forms preciſely the ſame ſubſtance as the preparation made in the moiſt way.

Hepatic air.

The peculiar fetid ſmell of the ſolid hepar when moiſtened, or of its ſolution, is produced by the emiſſion of a permanently elaſtic fluid, called hepatic air. This ſmell, when ſtrong, is inſupportable, and ſuddenly deſtroys animal life. Hepatic air is very ſoluble in water, which it converts into a ſtate perfectly reſembling that of the ſulphureous mineral ſprings. It renders ſyrup of violets green, blackens the calces of lead and biſmuth, and the ſurface of ſilver. Vital air decompoſes it, and cauſes ſulphur to be depoſited. It detoetonates with vital air when ſet on fire. It is not learly aſcertained in what manner the ſulphur is ſuſended in hepatic air. Sulphur, melted by the burnng glaſs, in inflammable air over mercury, produces fluid which has the properties of hepatic air; and if inflammable air be paſſed through melted ſulphur, becomes converted into hepatic air. As this air not obtained from hepar unleſs water be preſent, it as been ſuppoſed to conſiſt of ſulphur volatilized, in ombination with inflammable air, extricated by a deompoſition of the water; whoſe other component art, namely, vital air, is ſuppoſed to unite with the ulphur. It is even aſſerted that the reſidue contains itriolated tartar.

Hepatic air.

Volatile liver of ſulphur.

Fluid volatile alkali has very little action on ſulhur; but a volatile hepar may be produced by the nion of alkaline air with ſulphur in the vaporous ate. If equal parts of quick-lime and ſal ammoniac e mixed together with half a part of ſulphur, and iſtilled with the pneumatic apparatus (fig. 15 and 21), ith a ſmall quantity of water in the receiver, a rediſh yellow hepatic liquor will be obtained, which is he volatile hepar, and was formerly known by the ame of the fuming liquor of Boyle; ſo called from ts inventor, and from the white fumes it emits in the ir.

Balſams.

Sulphur combines with moſt metallic bodies in the ry way. Oils likewiſe diſſolve it, and form comounds called balſams.

Häſſenfratz in Phil. Tranſ. Vol. LXXVII. p. 306.

SULPHUR.

Combuſtion of ſulphur.

When ſulphur is heated in an open veſſel, it melts; and ſoon afterwards emits a blueiſh flame, viſible in the dark; but which, in open day light, has the appearance of a white fume. This flame has a ſuffocating ſmell; and has ſo little heat that it will not ſet fire to flax, and may even be ſuffered to play againſt the palm of the hand without any conſiderable inconvenience. In this way the ſulphur may be entirely conſumed. If the heat be ſtill augmented, the ſulphur boils, and ſuddenly burſts into a much more luminous flame; the ſame ſuffocating vapour ſtill continuing to be emitted.

Volatile vitriolic acid.

The ſuffocating vapour of ſulphur is imbibed by water, with which it forms the fluid called volatile vitriolic acid. If this fluid be expoſed for a time to the air, it loſes the ſulphureous ſmell it had at firſt, and the acid becomes more fixed. It is then the fluid which was formerly called ſpirit of vitriol. Much of the water may be driven off by heat; and the denſe acid which remains is the vitriolic acid, commonly called oil of vitriol: a name which was probably given to it from the little noiſe it makes when poured out; and the unctuous feel it has when rubbed between the fingers, produced by its corroding and deſtroying the ſkin, with which it forms a ſoapy compound.

Oil of vitriol.

Vitriol of iron.

The pyrites before mentioned, which conſiſt, for the moſt part, of ſulphur and iron, are found to be converted into the ſalt called vitriol of iron by expoſure to air and moiſture. In this natural proceſs the pyrites break, and fall in pieces; and if the change take place rapidly, a conſiderable increaſe of temperature follows, which is ſometimes ſufficient to ſet the

maſ

's on fire. By conducting this operation in an ırate way, it is found that vital air is abſorbed. vitriol is obtained by ſolution in water, and ſub- ent evaporation; by which the cryſtals of the ſalt ſeparated from the earthy impurities which were ſuſpended in the water.

Diſtillation of vitriol.

'he vitriolic acid was formerly obtained by diſtilla- from vitriol of iron. When this ſalt is expoſed to :, the vitriolic acid comes over, at firſt attended ı a large quantity of volatile ſulphureous vapour; , towards the end, there is a production of pure hlogiſticated air. The acid which riſes laſt has a crete cryſtalline form. The acid obtained in this ceſs is black, and requires to be purified by a ınd diſtillation, or rectification, in which the vola- ſulphureous acid comes over, and leaves the denſe iolic acid behind.

Manufacture of vitriolic acid.

Ioſt of the vitriolic acid now uſed is produced by combuſtion of ſulphur. There are three condi- s requiſite in this operation. Vital air muſt be ent, to maintain the combuſtion; the veſſel muſt be e, to prevent the eſcape of the volatile matter which s; and water muſt be preſent, to imbibe it. For e purpoſes, a mixture of eight parts of ſulphur with of nitre is placed in a proper veſſel, incloſed within ıamber of conſiderable ſize, lined on all ſides with l, and covered at bottom with a ſhallow ſtratum of er. The mixture being ſet on fire, and ſhut up, l burn for a conſiderable time, by virtue of the ſup- of vital air which nitre gives out when heated; l the water, imbibing the ſulphureous vapours, be- ıes gradually more and more acid, after repeated

com-

combuſtions; and the acid is afterwards concentrate by diſtillation.

Characters of vitriolic acid.

Pure vitriolic acid is colourleſs, and emits no fumes It ſtrongly attracts water, which it takes from th atmoſphere very rapidly, and in large quantities, i ſuffered to remain in an open veſſel. If it be mixe with water, it produces an inſtantaneous heat, nearl equal to that of ebullition. Its action upon all th earths except the ſiliceous, upon the alkaline ſalt upon many metals, and almoſt every other combuſtibl ſubſtance, is very ſtrong.

Combination of vitriolic acid and clay.

With argillaceous earth it forms alum. This wel known ſalt has a peculiar auſtere or aſtringent taſte ; ſoluble in about fifteen times its weight of water, the temperature of 60°, and in a much leſs quantity higher temperatures; from which it may be ſeparate in the form of permanent cryſtals. It fuſes at a m derate heat, and froths up till its water of cryſtalliz tion is evaporated; at which period it has the form a white friable ſubſtance, called calcined alum, whi retains the greateſt part of its acid when not t much heated; and may again be reſtored to its o ginal form by adding the water it had loſt by the he

Preparation of alum.

Alum is not made for the purpoſes of commer by a direct combination of the vitriolic acid and cl but is extracted from ſubſtances uſually called alu ores, which either are, or probably were originall compoſed of clay and ſulphur. From ſuch as cont the alum ready formed, as is the caſe with earths of t kind found in the neighbourhood of volcanos, it extracted by lixiviation in water, and ſubſequent e poration. But other ſubſtances, ſuch as pyrites al m ſlates, require to be burned or expoſed to the and moiſture for a time, before any alum can had from them. Theſe proceſſes convert the phur into vitriolic acid. Alum works have long n eſtabliſhed in Britain, and many other parts of world.

The acid in alum is not ſaturated. If a ſolution of m be boiled upon clay, a conſiderable portion of the er will unite with the ſalt, and form a combination ich is much leſs ſoluble than the alum itſelf.

Vitriolic acid with lime, p. 104.

With calcareous earth the vitriolic acid forms gypn, or plaſter of Paris. This ſaline ſubſtance is plenlly found in nature; and is known by different nes, according to its texture and external appeare. The lapis ſpecularis and alabaſter are of this d. It requires about five hundred times its weight water to diſſolve it at the temperature of 60°, and for that reaſon been reckoned an earth. Its chief has been already adverted to.

—with ponderous earth, p. 105:

With ponderous earth the vitriolic acid forms the derous ſpar, or marmor metallicum.

—with magneſia, p. 106:

With magneſia it forms Epſom ſalt, which has a er taſte. This is ſoluble in its own weight of er, at the temperature of 60°; and by evaporation recovered in cryſtals, which are diſpoſed to effloe, or become converted into a dry powder by expoe to air.

—with vegetable alkali.

With the vegetable alkali this acid forms a ſalt nmonly called vitriolated tartar, which is ſoluble in out ſixteen times its weight of water, at the tempeure of 60°; and from which it may again be recove by evaporation in the form of permanent cryſtals.

VITRIOLIC ACID.

Vitriolic acid with mineral alkali:

With the mineral or marine alkali, the vitriolic acid forms Glauber's ſalt, which requires only three times its weight of water to diſſolve it at the ſame temperature. It is more ſoluble in hot than cold water; and may therefore be ſeparated from a hot ſaturated ſolution, either by cooling or by evaporation. Its cryſtals are uſually large and well formed; but they loſe their water of cryſtallization, which amounts to near half their weight, by expoſure to the air, and fall into an efflorcſcence, or white powder.

—with volatile alkali:

The combination of the vitriolic acid with volatile alkali, is called vitriolic ammoniac. It is ſoluble in twice its weight of cold or an equal weight of hot water; and affords cryſtals either by cooling or evaporation, which are permanent, or ſlightly diſpoſed to attract moiſture and deliqueſce. Some chemiſts aſſert that it is volatile, and others affirm the contrary. Upon examination, it would probably be found that the acid or alkali, or both, are decompoſed by heat.

—with combuſtible matter.

Aeriform vitriolic acid.

Page 134.

When any combuſtible ſubſtance is added to the concentrated vitriolic acid, the fluid becomes black; and emits white vapours, which are of an exceedingly pungent ſulphureous ſmell; and, if received over mercury, are found to conſiſt of a peculiar aeriform fluid, which is not condenſable into the fluid ſtate except by a very great degree of cold *. It is ſoluble in water, which it converts into volatile vitriolic acid, of exactly the ſame nature as that obtained by the combuſtion o ſulphur. Whence it follows, that the fumes of ſulphur conſiſt of this kind of air, rendered viſible by

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* This was effected by M. Monge. See Fourcroy's Chemiſtry, Vol. I. p. xxxi.

th

VITRIOLIC ACID.

moiſture it meets and combines with in the atmo- re. Boiling vitriolic acid acts upon moſt metals, affords vitriolic acid air, and with ſome of them hur; but with ſuch metals as it can act upon n conſiderably diluted, it affords inflammable air. en this acid is diſtilled from metals to dryneſs, the r product is vital air.

Sulphureous acid.

he ſulphureous or volatile vitriolic acid forms ſaline binations with earths, alkalis, and metals; but its ction to theſe baſes is much leſs than that of the iolic acid. Expoſure to the air for a length of changes theſe ſalts into common vitriolic ſalts, he ſame manner, doubtleſs, as it changes the ſulreous acid into the common vitriolic acid.

Characters of vitriolic acid air.

itriolic acid air is heavier than common air; and, every other permanently elaſtic fluid, except vital nd its compounds, it extinguiſhes combuſtion, and roys animal life. If alkaline air be mixed with it, airs combine, and form a beautiful white cloud, ch becomes condenſed, and is found to be vitriolic oniac; at the ſame time that a yellow ſubſtance parated, which ſeems to be ſulphur. Water imnated with this air may be frozen without parting it; and if ſuch impregnated water be expoſed to for many days in a glaſs veſſel hermetically ſealed t is to ſay, cloſed by melting its aperture with a v-pipe), it depoſits ſulphur*.

Vitriolic acid converted into ſulphur.

he converſion of ſulphur into the vitriolic acid, , contrary-wiſe, of the acid into ſulphur, being cts of great importance in chemical theory; it bee a deſirable object to perform the latter, in order

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* Prieſtley, IV. 124.

VITRIOLIC ACID.

to confirm ſuch reaſoning as was adopted reſpecting the former. As it is evident that ſulphur becomes vitriolic acid by combuſtion, it muſt follow by analogy, from what happens in the revival or reduction of burned metals, or metallic calces, that ſulphur might be revived from vitriolic acid, by expoſing it to heat with ſome more combuſtible ſubſtance. A difficul however preſented itſelf in this attempt, which was that the vitriolic acid, being rendered volatile by th addition of a combuſtible body, would elude the at tempt to expoſe it to a conſiderable heat. This, n doubt, was the circumſtance that directed the atten tion of the great founder of the theory of phlogiſto (Stahl) to the neutral ſalts; in which the acid is n only highly concentrated, but combined with a mo fixed body, namely, the alkali. He fuſed equal par of fixed alkali and vitriolated tartar in a crucible; t which he added half a part of powdered charco This mixture being well ſtirred together, and heate ſtrongly for a very ſhort ſpace of time, was pour out, all ſparkling, upon a ſmooth ſtone previouſ greaſed. The compound, when cooled, was found be a true liver of ſulphur; from which, after ſoluti in water, and precipitation by adding an acid, the ſu phur was obtained.

Stahl's experiment for obtaining ſulphur from vitriolic acid.

Electricity.

When the electric ſpark paſſes between two ſurfac of vitriolic acid confined in a bended glaſs tube, th is a production of vital air.

Recapitulation and theory.

Such are the principal facts relating to ſulphur a the vitriolic acid; which, when conſidered with a vi to theoretical arrangement, are found to be more i mediately connected than at firſt view they may ſe

Theory.

be. The combuſtion of ſulphur is of the ſame
ature as every other combuſtion. Vital air is ab-
rbed, and the inflammable principle is ſuppoſed to be
xtricated. The ſulphur, thus deprived of its phlo-
iſton, and united to vital air, becomes an acid; which
not completely changed until, by ſubſequent expo-
ure to the common air, it has imbibed ſtill more of
e vital part, and the remaining phlogiſton has been
iſſipated. The decompoſition of pyrites is a pheno-
enon of the ſame kind, but is performed more gra-
ually, and of courſe with the accumulation of leſs
eat. The ſulphur of theſe combinations attracts the
ital part of the air by an action which is ſuppoſed to
e increaſed by the ſtrong tendency of the iron to
ombine with the acid that reſults from the union;
he phlogiſton being diſſipated for the ſame reaſon.
nſtead, therefore, of a combination of iron and ſul-
hur, they become converted into vitriol, in which an
cid is found: and as this proceſs conſiſts of the ab-
orption of vital air, and diſengagement of phlogiſton,
t is a true combuſtion; with this only modification,
hat the heat is ſeldom extricated ſo rapidly as to pro-
uce the appearances of ignition and flame, but is
onducted off by the ſurrounding bodies nearly as faſt
s it is generated.

Decompoſition of pyrites.

Black vitriolic acid.

In the diſtillation of vitriolic acid from vitriol of iron, the acid is rendered black and ſulphureous from the iron, which was not completely dephlogiſticated or calcined during its original combination with the acid: for the phlogiſton of the iron is ſuppoſed, in this diſtillation, to unite with the acid, and form ſulphur; while the portion of the vital air which con-

VITRIOLIC ACID.
Theory.

tributed to convert that ſulphur into acid, unites with the calx, and is afterwards driven off towards the end of the proceſs. A cryſtalline or concrete form of the acid is ſometimes produced by its holding the vitriolic acid air in ſolution. If this be driven off by heat, the acid will be pure. Hence it is clear that the volatile vitriolic acid differs in fact from the pure vitriolic acid, in the circumſtance that it holds ſulphur in ſolution. And the vitriolic acid air is the ſame acid with ſulphur, but with much leſs water, if any.

Mutual action of vitriolic acid and combuſtible bodies.

The change in the vitriolic acid produced by the addition of a combuſtible ſubſtance, is explained with equal facility; for it is the reverſe of the inflammation of ſulphur. The pure air of the acid is abſorbed by the combuſtible body; while the phlogiſton of this laſt unites with the baſe of the ſulphur, and forms ſulphur. This ſulphur renders the acid volatile; and it comes over in the aerial form, together with water. If the combuſtible body be of ſuch a nature as to leave a fixed reſidue, to which the laſt portions of acid may unite after all the water is diſſipated, ſulphur will come over alone. Or if all the ſulphur be driven off, either with the water or after it, the laſt product will conſiſt of the vital air which adhered to the reſidue, or fixed calx of the combuſtible body. When the diluted vitriolic acid acts upon a metal, and diſengages inflammable air, the acid unites entirely, and without decompoſition, to the calx, and the phlogiſton flies off in the aerial form.

Liver of ſulphur from vitriolated tartar.

An explanation nearly ſimilar may be applied to the formation of liver of ſulphur, when vitriolated tartar is fuſed with an alkali and charcoal. Vitriolated tartar,

Theory.

onſiſting of vegetable alkali united to vitriolic acid,
decompoſed by charcoal. This uniting with the vital
r of the acid, at the ſame time that it communicates
s phlogiſton to the baſe, converts the acid into ſul-
hur: the additional alkali ſerves only to aſſiſt the fu-
on of the original maſs, and to prevent the diſſipation
f the ſulphur by combining with it.

Antiphlogiſtic theory.

Thus far we have admitted the inflammable princi-
le in our explanation; and it muſt be admitted, if it
an be ſhewn that ſulphur contains it. We muſt
onfeſs however that this has not been proved; and
hat inflammable air has never been obtained directly
rom ſulphur, except a ſmall quantity, by paſſing ſteam
f water over it when heated in an earthen tube *; in
vhich caſe the original doubt preſents itſelf, whe-
her the air come from the ſulphur or the water. The
nodern theory, which rejects phlogiſton, accounts for
he preceding facts ſimply by the abſorption or extri-
ation of vital air. Sulphur is taken to be a ſimple
ıbſtance. The combuſtion of ſulphur conſiſts of the
apid combination of that ſubſtance with vital air;
vhich, at the ſame time, gives out its heat as its capa-
ity is diminiſhed. A ſmaller proportion of vital air,
vith the ſulphur, compoſes the volatile vitriolic acid,
vhether in the aerial form, or mixed with water: a
arger doſe forms the complete vitriolic acid. If a
ombuſtible body be added to vitriolic acid, this body
ecomes burned, or calcined, by uniting with part of
he vital air of the acid; the remainder conſequently
nas an over-proportion of ſulphur, and therefore be-
omes volatile. If the abſorption of pure air be ſuf-

Page 95.

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* Prieſtley, VI. 150.

VITRIOLIC ACID.

Theory.

ficiently copious, the acid is reſtored to its former ſtate, and becomes ſulphur again. When the combuſtible body is metallic, the pure air may, in ſome caſes, be driven out by heat from the reſidue. And laſtly, when inflammable air is obtained by the ſolution of metals in the diluted acids, it is taken for granted that it ariſes from the decompoſition of the water, whoſe vital air, uniting with the metal, conſidered as a principal ſubſtance, calcines it; while the inflammable part flies off, and the acid does nothing more than diſſolve the calx, and by that action facilitates its formation.

Detonation of hepatic air.

The detonation of hepatic with vital air may be readily explained on either hypotheſis; whether it be ſuppoſed to conſiſt chiefly, if not entirely, in the combuſtion of the ſulphur, which muſt by that mean be ſuddenly converted into vitriolic acid air; or ſimpl of the inflammable air, while the ſulphur is depoſited

CHAP

CHAP. II.

F THE NITROUS ACID, ITS COMPONENT PARTS, AND COMBINATIONS.

NITROUS ACID.

Production of nitre.

THE nitrous acid is obtained from the ſalt called nitre or ſaltpetre, which conſiſts of the acid itelf united to the vegetable alkali. This ſalt is never ound in conſiderable quantities in nature, but is evidently produced by a concurrence of circumſtances. The nitrous acid appears to be produced in all ſituaions where animal matters are completely decompoſed, with acceſs of air, and of proper ſubſtances with which it can readily combine. Grounds frequently rodden by cattle, and impregnated with their excrements; or the walls of inhabited places where putrid animal vapours abound, ſuch as ſlaughter-houſes, drains, or the like, afford nitre by long expoſure to the air. Artificial nitre beds are made by an attention to the circumſtances in which this ſalt is produced by nature. Dry ditches are dug, and covered with ſheds, open at the ſides, to keep off the rain: theſe are filled with animal ſubſtances—ſuch as dung, or other excrements, with the remains of vegetables; and old mortar, or other looſe calcareous earth, this ſubſtance being found to be the beſt and moſt convenient receptacle for the acid to combine with. Occaſional watering, and turning up from time to time, are neceſſary to accelerate the proceſs, and increaſe the ſurfaces to which the air may apply. After a ſucceſſion of many months, more or leſs, according to the management of the operation,

Nitre beds.

nitre is found in the maſs. If the beds contained muc
vegetable matter, a conſiderable portion of the nitrou
ſalt will be common ſaltpetre ; but, if otherwiſe, th
acid will, for the moſt part, be combined with th
calcareous earth.

Extraction of ſaltpetre.

To extract the ſaltpetre from the maſs of earth
matter, a number of large caſks are prepared, with
cock at the bottom of each, and a quantity of ſtra
within, to prevent its being ſtopped up. In theſe th
matter is put, together with wood-aſhes, either ſtrewe
at top, or added during the filling. Boiling water
then poured on, and ſuffered to ſtand for ſome time
after which it is drawn off, and other water added i
the ſame manner, as long as any ſaline matter can b
thus extracted. The weak brine is heated, and paſſ
through other tubs, until it becomes of conſiderab
ſtrength. It is then carried to the boiler, and contai
nitre and other ſalts ; the chief of which is commo
culinary ſalt, or the marine acid united to the miner
alkali, or ſometimes to magneſia. It is the property
nitre to be much more ſoluble in hot than cold wate
but common ſalt is ſoluble very nearly as much in co
as in hot water. Whenever, therefore, the evaporatio
is carried by boiling to a certain point, much of th
common ſalt will fall to the bottom, for want of wat
to hold it in ſolution, though the nitre will remain ſu
pended by virtue of the heat. The common ſalt th
ſeparated is taken out with a perforated ladle ; and
ſmall quantity of the fluid is cooled, from time to tim
that its concentration may be known by the nit
which cryſtallizes in it. When the fluid is ſufficien
ly evaporated, it is taken out and cooled, and gre

pa

ırt of the nitre ſeparates in cryſtals; while the re- aining common ſalt continues diſſolved, becauſe ually ſoluble in cold as in hot water. Subſequent aporation of the reſidue will ſeparate more nitre in e ſame manner.

Purification of nitre.

This nitre, which is called nitre of the firſt boiling, ntains ſome common ſalt; from which it may be ırified by ſolution in a ſmall quantity of water, and bſequent evaporation: for the cryſtals thus obtained e much leſs contaminated with common ſalt than fore; becauſe the proportion of water is ſo much rger, with reſpect to the ſmall quantity contained by ıe nitre, that very little of it will cryſtallize. For ice purpoſes, the ſolution and cryſtallization of nitre e repeated four times. The cryſtals of nitre are ſually of a priſmatic form.

Decompoſition of nitre by heat.

If nitre be expoſed to a ſtrong heat, it melts, and ecomes red hot; and the volatile product is found to onſiſt of fuming nitrous acid, a large quantity of tal air, and ſome phlogiſticated air; the alkali remain- ıg behind, ſomewhat altered by a portion of the earth f the retort which it has diſſolved. Moſt other nitrous ılts give out vital air by the ſame treatment. The xtreme difficulty of aſcertaining the weights of aerial roducts, and of the fixed reſidues, renders it an em- arraſſing taſk to ſhew by real experiment what hap- ens in this operation among the principles of nitre.

Deflagration of nitre.

When a combuſtible body and nitre are brought nto contact, either of them being previouſly heated ed hot, the body is burned with great rapidity, no loubt by the vital air which the nitre affords by the ıeat; for the experiment ſucceeds in vacuo, and alſo when

when the bodies are ſurrounded by any aerial fluid
incapable of maintaining combuſtion. This rapid
combuſtion, effected by means of nitre, is called defla-
gration, when it is performed by a ſucceſſive burning
Detonation. of the parts of the body; or detonation, when the com-
buſtion of the whole is performed in ſo ſhort a time
as to appear inſtantaneous. In this experiment it i
remarkable that the combuſtion is maintained by vita
air which is not in the elaſtic ſtate, but fixed in th
nitre. Whence it ſhould follow, that either the vita
air, or the combuſtible body, even in the fixed ſtate
has a great capacity for heat, of which it muſt contain
large quantity, on the hypotheſis of heat being matte
Or, if heat be a mere commotion, it will follow, tha
though the quantity of agitation produced by the ſud
den coalition of particles, in the act of converting a
elaſtic fluid into a denſe body, be ſuch as to produce
great effect in increaſing the temperature; yet th
quantity is ſtill ſo conſiderable, when vital air an
combuſtible matter unite even in their denſe ſtate,
to cauſe the moſt intenſe degree of ignition.

Invention of gunpowder. This property of nitre has been applied to the pro
duction of a ſubſtance which has greatly affected th
habits of human ſociety, particularly in thoſe wa
which unfortunately their vices too often produc
The invention of gunpowder has totally changed t
military ſyſtem of nations; and has probably ſuppreſſ
much of that malice and inveterate rancour whi
actuate the minds of combatants who meet hand
hand, inſtead of managing the inſtruments of indiſcr
minate ſlaughter at a diſtance. This deſtructive pow
der is compoſed of ſeventy-five parts by weight
nit

Compoſition of gunpowder.

re, ſixteen of charcoal, and nine of ſulphur, inti-
tely blended together by long pounding in wooden
rtars, with a ſmall quantity of water. This pro-
tion of the materials is the moſt effectual; but the
cumſtance on which its effect more particularly de-
ıds is, the accurate mixture of the parts. Gunpow-
· is granulated by making the maſs into a ſtiff paſte,
l agitating it upon a wire ſieve, which cuts it into
all parts; and theſe being ſhaken, or rolled in a
rrel, take a rounded form by their mutual friction
ainſt each other. When any grain of a heap of
npowder is ſet on fire, the detonation begins, and
propagated with amazing rapidity through the in-
ſtices of the grains; a large quantity of permanently
ıſtic fluid, conſiſting of one-third fixed air, and the
t phlogiſticated air *, being at the ſame time pro-
ced. The expanſion of the elaſtic products is the
uſe of the well-known effects of gunpowder. It is
d that gunpowder is much weaker for being granu-
ed. If the grains be pulverized, it is certain that
: effect is much leſs, on account of the inflammation
ing propagated more ſlowly; but the aſſertion may
vertheleſs be true of powder which is newly made,
d has never been grained. Gunpowder which has
en ſuffered to become damp, ſcarcely ever recovers
; former force; moſt probably becauſe the nitre, by
partial ſolution, becomes ſeparated from the maſs in
ore diſtinct ſaline cryſtals than before; and the
etting, which is neceſſary to the proceſs of granu-
ıting, may weaken the powder in the ſame way.

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* Berthollet, in the Mem. Acad. Par. 1781, page 231.

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Fulminating powder.

When three parts by weight of nitre, two of mi vegetable alkali, and one of flowers of ſulphur, a rubbed together in a warm mortar, they compoſe powder known by the name of fulminating powd The effects of this powder, when fuſed in a ladle, a then ſet on fire, are aſtoniſhing. The whole of t melted fluid explodes with an intolerable noiſe; a the ladle is commonly disfigured, as if it had receiv a ſtrong concuſſion downwards. A drachm of t powder makes a report as loud as a cannon; b the noiſe of a few grains is ſufficiently unpleaſant i room. It has very little effect, unleſs firſt melt A mixture of liver of ſulphur with twice its weig of nitre, produces the ſame exploſion, though in l time; whence it appears that the alkali and ſulp of the former preparation form a liver of ſulphur; that the exploſion, in all probability, ariſes from t ſudden extrication of hepatic air from the liver ſulphur, and vital air from the nitre, which burn t inſtant they are formed.

Diſtillation of nitrous acid.

If clay, bole, or alum, be mixed with nitre, and poſed to diſtillation, the nitre is decompoſed, and t acid comes over; the attraction between itſelf and t alkali being weakened, partly by the attraction wh the vitriolic acid uſually contained in thoſe bo has for its alkali, and partly by the attraction exer between the ſame alkali and the ſiliceous earth of t clay. If ſtrong vitriolic acid be added to nitre i retort, the ſame decompoſition takes place with application of much leſs heat, by virtue of the ſu rior attraction of the acid of vitriol to the alkal baſe.

NITROUS ACID.

Nitrous acid is uſually yellow, and emits ſuffocating
es of the ſame colour; but it may be rendered
and colourleſs by a ſlight boiling in a retort.
a fortis is a weak ſpirit of nitre, and not remark-
pure. It uſually contains ſome marine acid.
he aſſayers purify their nitrous acid by adding a
ll portion of the nitrous ſolution of ſilver. This
al unites with the marine acid it may contain, and
down in the form of an inſoluble compound.
e muſt be taken to avoid adding too much.

Nitrous acid; with lime:

This acid, in combination with calcareous earth,
ms a ſalt whoſe cryſtals deliqueſce by expoſure to
air. It is ſoluble in twice its weight of cold, or
own weight of boiling water. With ponderous
th, it forms a ſalt of difficult ſolubility. With
gneſia it forms an acrid bitter ſalt, which is very
ible in water, and deliqueſcent in the air. With
it forms an auſtere ſalt of difficult ſolution. None
theſe have yet been applied to any uſe.

—with ponderous earth; magneſia:

—and clay:

—with mineral alkali:

With the mineral alkali this acid forms a ſalt
ed quadrangular nitre, from the uſual form of its
ſtals. About three times its weight of water is
uired to hold it in ſolution in a mean temperature,
it is ſcarcely more ſoluble in hot water. Its
perties reſemble thoſe of common nitre; but it is
fit for making gunpowder, becauſe it attracts the
midity of the air.

—with volatile alkali.

The nitrous acid, in combination with the volatile
ali, forms nitrous ammoniac; a ſalt which ſlightly
racts the humidity of the air, and is ſoluble in leſs
n its own weight of water. If this ſalt be expoſed
heat in cloſed veſſels, it ſuddenly explodes; part of
the

the acid and alkali is deſtroyed; and the aerial product is phlogiſticated air.

Production of nitrous acid.

Nitrous acid produced; by Mr. Cavendiſh:

—by M. Thouvenel.

Inference.

If a mixture of two parts by meaſure of vital air obtained without the uſe of nitrous acid, and one o phlogiſticated air—or, which is the ſame thing, fiv parts of vital, and four of common air—be expoſe to the action of the electric ſpark in the upper par of a ſyphon, in which it may be confined by mercury and a ſmall quantity of ſoap lees, or ſolution of pur vegetable alkali, be admitted into the cavity whic contains the air; an abſorption will take place, an nitrous acid will be produced, as appears by the alka being converted into true nitre. This is a ſlow op ration, and requires the quantity of air in the ſ phon to be renewed very often, to ſupply the abſor tion *. It has likewiſe been found that this acid produced by expoſing vital air for a long time to th exhalations of putrifying animal ſubſtances, togeth with calcareous earth, or any other proper baſe receive and combine with it †. There can be lit doubt but the putrid exhalations conſiſted chiefly phlogiſticated air. It appears therefore that this ſu ſtance bears the ſame relation to the nitrous acid ſulphur does to the vitriolic. As ſulphur by combu tion, in which vital air is an indiſpenſable requiſi becomes converted into vitriolic acid; ſo phlogiſticat air becomes converted into nitrous acid; though,

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* For the detail of the particulars of this moſt curious ex riment, conſult Mr. Cavendiſh's papers, in the Phil. Tr Vol. LXXV. p. 372; and Vol. LXXVIII. p. 255.

† This is the diſcovery of M. Thouvenel. See his P Diſſertation on the Formation of Nitre.

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NITROUS ACID.

count of its being leſs combuſtible, the red heat
nnot be produced and kept up without the co-opera-
n of electricity: and as ſulphur, when in contact
ch the pure air of the atmoſphere, and with a baſe
oper for combining with the vitriolic acid, is con-
rted into that acid by a ſlow combuſtion in the
rites; ſo the like expoſure of phlogiſticated air, in
ntact with calcareous earth, to vital air, produces
trous acid, though much more ſlowly, becauſe the
ſe is leſs combuſtible.

Nitrous acid with combuſtible matter.

The nitrous acid acts with peculiar energy on com-
iſtible ſubſtances, which it burns or calcines; and
iring moſt of theſe proceſſes a peculiar kind of air
es off, which is called nitrous air. It is produced
the ſolution of many of the metals, by moſt vege-
ble, and ſome animal ſubſtances. This aërial fluid
not rapidly imbibed by water, and may therefore
r temporary uſe be received over it. It is not heavier
an common air; and poſſeſſes the remarkable pro-
erty of ſuddenly uniting with vital air, with which
forms nitrous acid. The mixture of theſe two
inds of air forms a red cloud, which is imbibed by
e water, and renders it acid, if the experiment be
erformed over that fluid; and, from examination of
his acid water, it is proved that the cloud is the ni-
rous acid itſelf. From this circumſtance Dr. Prieſtley
nſtituted a method of determining the purity or re-
pirability of the air of the atmoſphere, or any other
ermanently elaſtic fluid. He found, by a variety of
xperiments, that when nitrous air and any other air
re mixed, they undergo no change, if the latter be to-
ally unfit to ſupport combuſtion or animal life; but, if
the

Nitrous air, p. 94.

Dr Prieſtley's method of aſcertaining the reſpirability of air.

the contrary, the red cloud is formed; and the whole bulk of the mixture is diminiſhed by a quantity which is ſo much the greater, accordingly as the air in queſtion is of a quality more ſuited to thoſe purpoſes. This diminution he likewiſe proved to conſiſt of a proportional part of the air which is tried, together with as much of the nitrous air as is required to produce the effect; ſo that, if the nitrous air be duly proportioned to the effect, it will wholly diſappear.

Imperfections of the trial of air by nitrous air.

The trial of the purity of common air by means of nitrous air, has not however been found to exhibit ſuch remarkable differences between the air taken up at various places as their known ſalubrity or unhealthineſs might have given reaſon to expect. Two reaſons may be offered to account for this. The firſt is, that a ſmall difference in the purity of the air of a place may have a very conſiderable effect on the health of thoſe who are obliged to breathe it for a long ſucceſſion of time: the ſecond is, that, the effects of nitrous air being the ſame upon elaſtic fluids which contain equal proportions of vital air, however greatly their other component parts may differ in their properties, it will only be ſhewn that the airs are equally ſalubrious, as far as depends on their proportion of vital air, though they may by no means be ſo with regard to their noxious parts.

Eudiometers.

There are ſeveral ingenious contrivances, called eudiometers, for the mixing of nitrous and other airs and meaſuring their diminution. As theſe however are not eaſily procured, and more eſpecially as Dr Prieſtley, whoſe experience is greater than that of any other philoſopher, uſes a ſimple tube, it does not ſeem neceſ-ceſſary to deſcribe them here. The doctor's method as follows:

Dr. Prieſtley's method of aſcertaining the purity of air.

He firſt provides * a phial containing about an ounce water, which he calls the air meaſure. This he s with air, by having firſt filled it with water, and aced it over the opening of the funnel, in his ſhelf g. 15); and when it is filled, he ſlides it along the elf, always obſerving that there be a little more air an is wanted. The phial being thus exactly filled th the air he is about to examine, and care being ken that it be not warmed by holding in the hand, empties it into a jar of about an inch and a half diameter; and then introduces to it the ſame mea- re of nitrous air, and lets them continue together out two minutes. The Doctor chooſes to have an erplus of nitrous air, that he may be ſure that its ect may be the utmoſt poſſible. If he finds the minution of theſe two meaſures to be very conſide- ble, he introduces another meaſure of nitrous air; t the pureſt vital air will not, he believes, require re than two meaſures of nitrous air.

Sometimes he leaves the common and nitrous air the jar all night, or a whole day; but he always es care, whenever he compares two kinds of air, t both ſhall remain the ſame length of time in the ſels, before he notes the degree of diminution.

When the preceding part of the proceſs is over, he nsfers the air into a glaſs tube, about three feet long, d one third of an inch wide, carefully graduated ac- rding to the air meaſure, and divided into tenth and

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* Prieſtley, IV. p. 30. I give the account nearly in his words.

hundredth parts; ſo that one of the hundredth parts will be about a ſixth or an eighth of an inch. Then immerſing the tube in a trough of water, ſo that the water in the inſide of the tube ſhall be on a level with the water on the outſide, he obſerves the ſpace occupied by the aerial mixture; and expreſſes the reſult in meaſures and decimal parts of a meaſure, according to the graduation of the tube.

Eudiometer tube.

It is ſome trouble to graduate a tube in this manner; but when it is once done, the application of it is extremely eaſy. As it ſeldom happens that a glaſs tub is of an equal diameter throughout, the Doctor generally fills that part of the tube which contains on meaſure with quickſilver; and then weighing it an dividing it into ten parts, he puts them in ſeparatel in order to mark the primary diviſions. The weighing is rendered very eaſy by the help of a glaſs tub drawn to a fine orifice, which ſerves to take up ſmall quantity at a time, as may be required in makin the adjuſtment.

Page 92.

It has been already obſerved that common air loſ about one fourth of its bulk by any proceſs equivale to combuſtion. This alſo happens when it is mix with nitrous air.

Action of nitrous acid on animal ſubſtances.

When the nitrous acid acts upon the fleſh, or oth parts of animal ſubſtances, the elaſtic fluid which firſt and moſt plentifully diſengaged is phlogiſticat air. In this experiment the phlogiſticated air m come from the animal ſubſtance, or the acid, or bot ſince both contain it. It appears however to be mu more probable that the whole comes from the anin ſubſtances; for it is afforded by the application o

v

NITROUS ACID.

ık nitrous acid, at ſo low a temperature as 65° both which circumſtances do not appear to a decompoſition of the acid. The nitrous er its action, ſaturates as large a quantity of before *. The quantity of phlogiſticated air oportion to the quantity of volatile alkali ıe animal ſubſtance made uſe of affords by n: and it is known that the quantity of phlogi air contained in any animal ſubſtance muſt s proportion. And, laſtly, at a greater heat, phlogiſticated air has come over, there is a :ment of nitrous air, which indicates a leſs decompoſition of the acid than that which ve afforded phlogiſticated air: and it is not t with other chemical facts, that the complete ition of the acid ſhould happen at a lower the partial decompoſition which ſucceeds it.

Page 124.

will imbibe about one tenth of its bulk of .r, which, if immediately expelled by heat, is to be changed in its properties. The re- hich is not imbibed is phlogiſticated air. ɔlic acid abſorbs nitrous air, and aſſumes a lour. The marine acid imbibes it, and be- ıe. Ether, alkaline liquors, and ſpirit of abſorb it.

Various fluids imbibe nitrous air.

:ctric ſpark diminiſhes nitrous air about one

Diminution of nitrous air by electricity, &c.

ɔantity of alkali ſaturated by any acid being different ɔ the ſtate of the acid, with regard to what is called on, this proof cannot be admitted as abſolutely con- eſs the ſame quantity of true nitre be formed in both not find whether this has or has not been done. de Chimie, I. 42.

half,

half, and converts it into phlogiſticated air, at the time that acid is depoſited. Iron filings and b ſtone, liver of ſulphur, or iron alone, being expoſ nitrous air, diminiſh it, and convert it into phlo cated air. But the moſt ſingular circumſtanc theſe proceſſes is, that, though they are of the n of combuſtion, and do in the end render air per unfit for maintaining it, yet, at a certain period this, the air is put into a ſtate in which a candle in it better than in common air, though it ſtill nues perfectly deſtructive of animal life. Dr. P calls this dephlogiſticated nitrous air.

Dephlogiſticated nitrous air.

Abſorption of nitrous air by the nitrous acid.

If nitrous acid be expoſed to nitrous air, th is abſorbed in large quantities; and the colour acid changes firſt at the ſurface, and gradually t the whole of the liquid: the ſucceſſions of col firſt yellow, then deep orange, next green, an blue, according to the quantities of nitrous air a This abſorption renders the acid much more Hence it appears that the various colours of acid are owing to its having abſorbed nitr which continually eſcaping, and combining vital air of the atmoſphere, forms the yellow o fumes it uſually emits when in an open veſſel.

Pale nitrous acid, becomes yellow:

— is capable of the elaſtic form.

The pale or dephlogiſticated nitrous acid poſed to the action of light, gives out pure itſelf becomes yellow and fuming. Heat alſo the ſame effect. The nitrous acid itſelf app capable of ſubſiſting in the aerial form, th power of combining with water, mercury other fluid uſed for confining it, prevents ex from being made upon it with the ſame

NITROUS ACID.

ther kinds of air. Water impregnated with or vapour becomes ſucceſſively blue, green, and ellow, when it has received an increaſe of one f its bulk. This water emits a great quantity ous air, and does not ſeem to differ eſſentially ure nitrous acid which has imbibed nitrous air.

Inflammation of eſſential oils by nitrous acid:

of the earlieſt known facts of ſpontaneous in- tion is that produced by the affuſion of the acid upon oil. All the oils obtained by diſtil- from vegetables, and known by the name of l oils, are proper for this experiment. An of the oil intended to be ſet on fire muſt be in a ſhallow veſſel, and a bottle containing an of the moſt concentrated nitrous acid muſt be d at the end of a pole, that the operator may ficiently diſtant from the inflammation. Two of the acid being poured on the oil, makes a rable ebullition; the oil growing black and and ſometimes taking fire. But if this laſt cir- ance does not happen in five or ſix ſeconds, the der of the acid muſt be poured where the mix- pears moſt dry and black; and then the inflam- ſeldom fails to take place.

— of fat oils:

oils may alſo be inflamed, if equal parts of the s and vitriolic acids be firſt poured on them, hen the ebullition is at the greateſt, a portion of s acid be poured on the drieſt part.

—of charcoal, or lamp black.

ong nitrous acid, of the ſpecific gravity of 1.54, added to the powder of charcoal, or lamp *, recently made very dry, takes fire, and deto- nates.

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* Prouſt in the Journal de Medecine, for July 1778.

NITROUS ACID.

nates. There is ſome uncertainty in this experime
but the method which is ſaid to enſure ſucceſs, is
put the dry powder into a very dry retort, and p
the acid upon the ſide of the glaſs, ſo that it may
fall upon the powder, but flow beneath it.

The production of heat in theſe phenomena, wh
doubtleſs ariſes from the action exerted between
combuſtible body and the vital air of the acid, has
yet been explained in an adequate manner from exp
ments, tending to ſhew how the capacities of the b
are changed by the proceſs.

Recapitulation and theory.

On a review of the facts in the foregoing chap
it will not be difficult to apply in a general way
ſame theories as were exhibited in treating of th
triolic acid. The preparation of nitre beds co
ſimply in a proceſs by which the exhalations of p
ſubſtances may combine with vital air, and the pro
be received into a combination with calcareous e
or with the alkali of decayed vegetables; and
ſubſequent manipulations are the mere applicatio
water, to ſeparate the ſeveral matters from each o
according to their reſpective degrees of ſolub
That nitrous acid contains vital air, is evident f
the diſtillation of nitre without addition; and tha
the acid it is applied to, or combined with, phlog
cated air, appears equally clear from the * experi
of Mr. Cavendiſh, and from the frequent appear
of this aerial ſubſtance in experiments with nit
air. The queſtion in this proceſs therefore ſeem
be, whether the air called phlogiſticated air do n

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* Phil. Tranſ. quoted, page 152.

co

ntain an inflammable principle, which it gives out
riug combination with the vital air; or whether it
ıply unite to this laſt? Upon the former ſuppoſition,
: theory of the general facts will be as follows:
Nitrous acid conſiſts of vital air united to a certain
ɔportion of phlogiſticated air, which has been de-
ived of phlogiſton during combination. When a
mbuſtible body is preſented to this acid, it becomes
rroded or burned; that is to ſay, it combines with Theory.
ne of the vital air, and parts with ſome of its own
logiſton. In this ſtate the acid is no longer the
ne; for it has loſt vital air, and part of its phlogiſti-
ted air has regained phlogiſton. It therefore emits Page 159.
her nitrous air, which is an imperfect nitrous acid,
ıerein the phlogiſton is too abundant, and the vital
too deficient, to exhibit acid properties; which on
ıt account readily abſorbs vital air, and is by that
ans precipitated again in the original acid form:
if the decompoſition be more completely made, the Page 162.
antity of vital air abſorbed, and of phlogiſton emit-
l, by the combuſtible body, may be ſuch as that only
logiſticated air ſhall be extricated, as is the caſe with
imal ſubſtances. Again, the compoſition of nitrous
being thus eſtabliſhed, if the electric ſpark be Page 163.
plied to produce ignition in this aerial fluid, the
ıall portion of vital air intimately unites with as
uch of the phlogiſticated air as is required to form
trous acid, and leaves the reſidue of phlogiſticated Ibid.
r behind: or, if any proceſs of ſlow combuſtion be
rried on in it, the whole of the vital air is abſorbed,
ıd as much phlogiſton extricated as converts the re-
lue into phlogiſticated air. It is evident that the Page 164.

NITROUS ACID.

abſorption of nitrous air muſt equally alter the proportions of the component parts of the nitrous acid, and produce ſimilar effects.

The ſingular properties of the air called dephlogiſticated nitrous air have not been ſatisfactorily explained upon any theory.

Theory:

It is obvious that the explanation of theſe events may be made at leaſt with equal facility according to the other theory.

— of the antiphlogiſtians.

Phlogiſticated air and vital air are applied to each other under certain circumſtances, and nitrous acid is produced. Hence it is concluded that theſe aerial ſubſtances have united together, and are the component parts of nitrous acid. When an inflammable ſubſtance is burned, or a metal calcined, by the action of this acid, one of its component parts, namely, vital air, unites with the body; and the ſurplus of the other principle, namely, phlogiſticated air, flies off either alone, or in combination with a ſufficient portion of vital air to form nitrous air. The addition of vital air to this laſt aerial product completely forms nitrous acid; the ſubtraction of the vital air it poſſeſſes muſt change it into phlogiſticated air.

Action of light.

The phenomenon of nitrous acid becoming yellow and fuming by the action of light or heat, will ſhew that it receives phlogiſton, according to the ancient hypotheſis. As it ſeems however to be a bold ſuppoſition, that either light or heat, conſidered as matter, can transfer the inflammable principle through glaſs veſſels, the fact has been more ingeniouſly explained by recourſe to the decompoſition of water. It is aſſerted that the nitrous acid attracts the inflammable air, or phlogiſton, of the water, and ſets its vital air at

liberty.

NITROUS ACID.

Theory.

rty. According to the antiphlogiſtic theory, it is ply ſaid that heat or light expels part of the vital from the nitrous acid, as the event ſhews; and that reſidue, having an over-proportion of phlogiſti- d air, is of courſe coloured and fuming.

he reader may eaſily apply theſe theories to the ıbuſtion of oils or charcoal by the nitrous acid, as as the facts can be clearly ſtated, or are known: theſe are doubtleſs of the ſame nature as other ıbuſtions.

Keir's compound acid. See Chap. II. Book II.

t is a late diſcovery of Mr. Keir*, that a mixture the concentrated vitriolic and nitrous acids forms a ent peculiarly calculated to diſſolve ſilver in a large portion; though it has ſcarcely any efficacy in ſuſ- ıding any other metallic ſubſtance. He forms it diſſolving nitre in concentrated vitriolic acid. Tin, rcury, and nickel, are acted upon, and chiefly cal- ed, by this compound acid; the latter being diſ- ed in a ſmall quantity: but it has little or no action n the other metals. Dilution with water renders ſs capable of diſſolving ſilver, but more active with ard to the other metals.

f this acid be digeſted upon ſulphur, it undergoes change called phlogiſtication, and emits nitrous nes; the nitrous acid probably loſing its acidity proportion as the ſulphur becomes acidified. Its affi- ies, or ſolvent powers, are conſiderably changed by s proceſs. The ſame phlogiſticated acid is afforded, the nitrous vapour or air be added to vitriolic acid, ſtead of common nitre; or if nitre with baſis of latile alkali be uſed.

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* Phil. Tranſ. Vol. LXXX. p. 373.

CHAP.

CHAP. III.

OF THE MARINE ACID AND ITS COMBINATIONS, INCLUDING AQUA REGIA.

COMMON SALT.

Salt mines and ſprings.

THE marine acid is obtained from common culinary ſalt, in which it is united to the minera alkali. Common ſalt is found in large maſſes, or i rocks, under the earth, in England and elſewhere There are alſo many ſalt ſprings in various parts o the world; and the waters of the ocean every wher abound with it, though in different proportions. Th water of the Baltic ſea * is ſaid to contain one ſixty fourth of its weight of ſalt; that of the ſea betwee England and Flanders contains one thirty-ſecond part that on the coaſts of Spain one ſixteenth part; an between the tropics it is ſaid, perhaps erroneouſly to contain from one eleventh to one eighth part.

Sea water.

Extraction of common ſalt from waters.

The whole art of extracting ſalt from waters whic contain it, conſiſts in evaporating the water in th cheapeſt and moſt convenient manner. In England a brine compoſed of ſea water, with the addition o rock ſalt, is evaporated in large ſhallow iron boilers and the cryſtals of ſalt are taken out in baſkets. I Ruſſia, and probably in other northern countrie the ſea water is expoſed to freeze; and the ice, whic is almoſt entirely freſh, being taken out, the remai ing brine is much ſtronger, and is evaporated by boi

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* Rome de l'Iſle's Cryſtallographie, Vol. I. p. 375, quoted b Magellan in his improved edition of Cronſtedt, p. 360.

ing. In the ſouthern parts of Europe the ſalt-makers take advantage of ſpontaneous evaporation. A flat piece of ground near the ſea is choſen, and banked round, to prevent its being overflowed at high water. The ſpace within the banks is divided by low walls into ſeveral compartments, which ſucceſſively communicate with each other. At flood tide, the firſt of theſe is filled with ſea water; which, by remaining a certain time, depoſits its impurities, and loſes part of its aqueous fluid. The reſidue is then ſuffered to run into the next compartment; and the former is again filled as before. From the ſecond compartment, after a due time, the water is transferred into a third, which is lined with clay, well rammed, and levelled. At this period the evaporation is uſually brought to that degree, that a cruſt of ſalt is formed on the ſurface of the water, which the workmen break, and it immediately falls to the bottom. They continue to do this until the quantity is ſufficient to be raked out, and dried in heaps. This is called bay ſalt.

Various methods —of obtaining ſalt. — from the waters

In ſome parts of France, and alſo on the coaſts of China, they waſh the dried ſands of the ſea with a ſmall proportion of water, and evaporate this brine in leaden boilers.

— of the ſea

At ſeveral places in Germany, and at Montmarot in France, the waters of ſalt ſprings are pumped up to a large reſervoir at the top of a building or ſhed; from which it drops or trickles through ſmall apertures upon boards covered with bruſh wood. The large ſurface of the water thus expoſed to the air, cauſes a very conſiderable evaporation; and the brine is afterwards conveyed

— and ſalt ſprings.

veyed to the boilers for the perfect ſeparation of the ſalt.

Salts contained in the ſea.

The water of the ſea contains, beſides the common ſalt, a conſiderable proportion of magneſian marine ſalt, and ſome gypſum, or lime combined with vitriolic acid. The magneſian ſalt is the chief ingredient of the remaining liquid which is left after the extraction of the common ſalt, and is called the mother water. Sea water, if taken up near the ſurface, contains alſo the putrid remains of animal ſubſtances, which render it nauſeous, and in long continued calms cauſe the ſea to ſtink.

Cryſtallization of common ſalt.

The cryſtals of common ſalt are right-angled ſix-ſided ſolids, and are uſually ſaid to be cubes. Theſe form at the ſurface, where the evaporation is the greateſt; and they float by virtue of the repulſive power of their dry upper ſurfaces, which diſplaces a quantity of the ſurrounding water: a circumſtance common to all ſuch ſmall bodies as are not eaſily wetted. When the cryſtal becomes too large to be ſuſpended in this way, it ſinks. If two floating cryſtals come ſo near each other as that the hollow ſpaces may communicate, they fall together into one cavity at the ſurface, without ſinking; and the ſucceſſive appoſition of other cryſtals often produces a curious hollow pyramid, which is ſquare, becauſe the figure of the cryſtals themſelves occaſions them to apply to each other only in the poſition required to produce ſuch a ſolid.

Common ſalt does not alter in the air; but when expoſed to heat, it cracks and flies in pieces, by the eſcape of its water of cryſtallization. A greater heat ignites and melts it; and a ſtill greater cauſes it to riſe totally in white fumes. The action of ſea ſalt upon earths is not conſiderable. It aſſiſts the fuſion of ſiliceous earth; and is thrown into the furnace wherein the pottery called ſtone-ware is baked, where it riſes in fumes, and glazes their ſurface; probably by the combination of its alkali with the ſiliceous earth contained in the clay. The decompoſition of ſea ſalt by litharge has already been mentioned in treating of the mineral alkali.

Page 118.

Diſtillation of marine acid from common ſalt.

The marine acid may be obtained from common ſalt by proceſſes ſimilar to thoſe deſcribed for procuring the nitrous acid in the preceding chapter. The moſt effectual and elegant way conſiſts in applying one part by weight of ſtrong vitriolic acid to three of decrepitated ſea ſalt, in a retort whoſe upper part is furniſhed with a tube or neck, through which the acid is to be poured upon the ſalt. The aperture of this tube muſt be immediately cloſed with a ground ſtopper after the pouring. The vitriolic acid immediately combines with the alkali, and expels the marine acid in the form of a peculiar air; which is rapidly abſorbed by water, but may be confined by mercury. As this combination and diſengagement take place without the application of heat, and the aerial fluid eſcapes very readily, it is neceſſary to arrange and lute the veſſels together before the vitriolic acid is added, and not to make any fire in the furnace until the diſengagement begins to ſlacken; at which time it muſt be very gradually raiſed. Before the modern improvements in chemiſtry were made, a great part of the

Marine acid air.

MARINE ACID.

Diſtillation.

the acid eſcaped, for want of water to combine with; but by the uſe of the apparatus, fig. 21 or 22 (or a combination of veſſels equivalent to both of them), the acid air is made to paſs through water, in which it is condenſed, and forms marine acid of double the weight of the water, though the bulk of this fluid is increaſed one half only. The acid condenſed in the firſt receiver, which contains no water, is of a yellow colour, ariſing from the impurities of the ſalt.

Marine acid air:

Heat expels the marine acid air from marine acid, and leaves the water behind. The fumes of ſpirit of ſalt conſiſt of this air in the act of uniting with the watery vapours of the atmoſphere, which render it viſible. This air has nearly the ſame affinities as the acid itſelf in the fluid form. The electric exploſion diminiſhes it a little; but the remainder is almoſt totally ſoluble in water as before.

— its corroſive nature.

It is an object of conſiderable importance to the practical chemiſt, to be aware of the corroſive nature of this acid air. If the proceſſes in which it is ſet at liberty be carried on in a room where balances and other metallic inſtruments are kept, though the quantities may not be perceptible by the ſmell or otherwiſe, yet the inſtruments will in the courſe of a few days be covered with ruſt. It is indeed by no means prudent to keep, or make uſe of, any delicate metallic inſtruments in the ſame apartment which is appropriated to chemical proceſſes.

Salt of Sylvius.

The marine acid, in combination with the vegetable alkali, forms a ſalt called ſalt of Sylvius, or, improperly, regenerated ſea ſalt. It is of a bitter taſte, ſlightly deliqueſcent, and ſoluble in about three times reight of water. This is ſometimes uſed in me- ie.

Sal ammoniac.

ith the volatile alkali it forms common ſal am- ac, which is a conſiſtent ſalt, of a ſharp briny ; and ſo remarkably deficient in the uſual brittle- of this claſs of bodies, that it is not eaſily pul- ed. It is ſoluble in between three and four times reight of water, in a common temperature. By it ſublimes entire in cloſed veſſels.

Marine ſelenite.

he ſaline combination of lime with marine acid is etimes called marine ſelenite, and ſometimes fixed ioniac; becauſe it forms the fixed reſidue after ſal ioniac has been expoſed to diſtillation with lime. ſalt may be obtained in the form of cryſtals, but liqueſces with air. It is ſoluble in leſs than twice weight of cold water. The combination of lime marine acid which remains after diſtilling ſal am- iac, has uſually an over-proportion of lime. If it rged by a violent heat, it fuſes; and when cold, is the property of emitting a phoſphoric light ı being ſtruck with any hard body. Hence it is d Homberg's phoſphorus, from the name of the obſerver.

Homberg's phoſphorus.

Argillaceous marine ſalt.

he argillaceous marine ſalt has a gelatinous con- nce when diſſolved in a ſmall quantity of water. aſte is ſtyptic, and it affords cryſtals by ſpontaneous ɔoration.

Ponderous marine ſalt.

he combination of ponderous earth with marine ı forms a cryſtallizable ſalt of difficult ſolution. ſolution is of admirable uſe for detecting the pre- cc of the vitriolic acid in any fluid; becauſe this combines with the earth, and forms an inſoluble precipitate of ponderous ſpar. It is more eſpeciall uſeful for purifying the marine acid itſelf from th vitriolic acid, which it often contains. The exac quantity of ſolution neceſſary to be added for thi purpoſe to any veſſel of marine acid, may be known b previous trials with ſmall portions of the acid.

Magneſian marine ſalt.

Magneſian marine ſalt exiſts in all ſalt waters. It i ſoluble in leſs than its own weight of water; and cannot be obtained in the cryſtalline form but by fir evaporating its ſolution, and then ſuddenly expoſing to a great degree of cold. It is the cauſe of the bi terneſs of ſea water; and, like moſt of the other ſa laſt deſcribed, it is applied to no uſeful purpoſe.

Action of marine acid upon metals.

The marine acid has ſcarcely any action upon combuſtible ſubſtances in general. It acts directly upo tin, lead, copper, iron, zinc, biſmuth, antimony, manganeſe, arſenic; but does not affect gold, ſilver, platina mercury, wolfram, or cobalt.

Dephlogiſticated or aerated marine acid.

If the marine acid be diſtilled from about one fourt of its weight of the black calx of manganeſe, a ſuffo cating elaſtic fluid ariſes, which corrodes mercury, an is abſorbed by water. The impregnation of water wit this fluid (which was named the dephlogiſticated marine acid by its diſcoverer SCHEELE) may be conveniently performed by means of the apparatus, fig. 21 If the concentrated marine acid be uſed, the diſengag ment takes place without heat; but if it be weake the application of a gentle heat is neceſſary. Th common marine acid which may riſe is condenſed i the firſt bottle; and the dephlogiſticated acid unites

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* Berthollet, in the Mem. Acad. Par. for 1785; and in R zier's Journal for Sept. 1788.

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MARINE ACID.

Dephlogiſticated or aerated marine acid.

water in the ſecond; the water, as it becomes ſa- ated, aſſumes a greeniſh yellow colour. When the uration is complete, the dephlogiſticated acid takes oncrete form, and deſcends to the bottom in yel- iſh flocks, provided the temperature of the water only a few degrees above freezing. An increaſe temperature, ſuch as may be produced by applying hand to the veſſel, cauſes this concrete matter to ıme the aerial form, and eſcape in bubbles to the face. The taſte of the ſolution is auſtere, but does t reſemble that of acids. It combines with fixed alis without cauſing them to give out their fixed , if they be in a mild ſtate. Heated with lime, or ed alkali, it emits vital air, and then forms the ne ſaline combinations as the common marine acid uld have done. It diſſolves all metals directly, thout affording inflammable air, as the marine acid es with ſome of them; and its ſaline combinations , for the moſt part, the ſame as the common acid duces when made to combine with thoſe bodies. deſtroys vegetable colours, rendering them white thout firſt cauſing them to become red; it bleaches x; and in general produces immediately, in a va- ty of ſubſtances, the ſame changes as are effected long expoſure to air. This property has already en applied with ſucceſs in manufactories.

Annales de Chimie, II. 151—190.

Salt into which dephlogiſticated marine acid enters.

When the aeriform dephlogiſticated marine acid received in a ſolution of pure vegetable alkali, and liquor evaporated, two kinds of ſalt are obtained. e one is the common ſalt of Sylvius, which ſepa- tes from the fluid as the evaporation goes on; and other is a ſalt which, being more ſoluble in hot

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Detonating marine ſalt; with baſe of vegetable alkali:

than in cold water, affords cryſtals by cooling. Theſe are of a long rhomboidal figure, and a ſilvery brilliancy; have an inſipid cooling taſte, reſembling nitre; do not deliqueſce in the air; and detonate with charcoal, or with iron, more ſtrongly than nitre itſelf does. By heat alone they give out vital air; and the reſidue of their detonation with charcoal is the ſalt of Sylvius. Hence it is obvious that a portion of the alkali has imbibed ſome of the dephlogiſticated marine acid, together with the overplus of vital air contained in a great part of the reſt of the acid; and that this alkali forms the preſent ſalt; while the acid which was deprived of the overplus, and by that means reduced to the common ſtate, forms the ſalt of Sylvius, which is in much the greateſt proportion in the ſolution.

— with mineral alkali:

If the mineral alkali be uſed, a ſalt nearly of th ſame nature is formed; but too deliqueſcent to affor cryſtals.

—volatile alkali.

Volatile alkali is decompoſed by the dephlogiſticate marine acid; the vital air combining with its inflammable part, and the phlogiſticated air flying off.

Action of light.

When the ſolution of dephlogiſticated marine aci is expoſed to the action of light, it emits vital air, an becomes converted into common marine acid.

Theory.

When we reaſon by analogy from the vitriolic an nitrous to the marine acids, we muſt conclude tha this laſt conſiſts of a baſe of a combuſtible natur united to vital air. And as the greater combuſtibilit of ſulphur, the baſe of the vitriolic acid, when compared with phlogiſticated air, or the baſe of nitrou acid, appears to be the cauſe why the action of th latter is more generally effectual upon combuſtib bodie

Theory.

ies, to which it can with more facility transfer its l air, and probably receive phlogiſton from them at ſame time; ſo the baſe of marine acid, being ap- ntly leſs combuſtible than even that of the ni- ıs, may, in its ordinary ſtate of acidity, hold too ll a quantity of vital air, or too large a proportion ɪhlogiſton, to act with energy on other combuſtible es. But whenever it is combined with a ſurplus ital air from the calx of mangaueſe (which cer- ly contains it, becauſe it affords it by ſimple heat), ıuſt act with great effect on bodies which are diſ- ·d to combine with that principle, for the ſame on as the nitrous acid does; namely, becauſe it is y decompoſed. And this reaſon will in fact be ſame, whether the action of acids be conſidered ɪrding to the modern theory, as conſiſting chiefly he combination of vital air with the combuſtible :/; or whether this laſt be ſuppoſed in the old ry to afford phlogiſton to the baſe, or other com- ɜnt part, of the acid.

Action on combuſtible bodies.

muſt be confeſſed however that the general cir- ſtances attending the change which the marine ſuffers by the acceſſion of vital air, are not ſtrictly onant throughout with what happens to the r acids. The phlogiſticated vitriolic and nitrous s are rendered more acid by the addition of vital which is generally admitted to be the chief prin- e of acidity. The marine acid, on the contrary, its activity increaſed, by ſuch an addition or ıge, only with reſpect to combuſtible bodies; but ɜſs active on the alkalis and earths, inſomuch that ɜ writers have thought it might be denied to be an

Acidity of marine acid does not vary after the law of other acids.

acid.

AQUA REGIA.

Theory.

acid. From this inſtance acidity appears to have its limits, ſo as to conſiſt of a preciſe term of dephlogiſtication, or of ſaturation with vital air; and to be impaired or deſtroyed by an exceſs either way. A full and adequate explanation of the changes of the marine acid cannot but afford much advantage to th general theory of acids, which occupy ſo large a ſpac among the objects of chemical inquiry.

Compoſition of aqua regia:

When one or two parts of pale concentrated nitro acid are mixed with four parts of fuming marine aci an effervefcence ſoon takes place *, and dephlogiſt cated marine acid flies off in the aerial form, at th ſame time that the mixture becomes of a deep re colour. The mixed acid is called aqua regia; and h been long remarkable for its property of diſſolvi gold, which is not ſenſibly acted upon by either of th acids that compoſe it.

—otherwiſe.

Aqua regia may be made by adding to nitrous ac any ſalt which contains the marine acid: for the a nity of the nitrous acid to the baſe being in mo caſes ſtronger than that of the marine, this laſt is ſ at liberty; and conſequently the mixture, if the ſ be not exceſſive in quantity, will contain the ac in a diſengaged ſtate. An aqua regia will ther fore be produced, which is not eſſentially impair with reſpect to common uſes by the portion of ſ it may hold in ſolution. It is uſual to make aq regia by diſſolving ſal ammoniac in about four tin its weight of ſtrong nitrous acid; but the reſ

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* Berthollet, in Acad. Par. 1785.

experiments or operations muſt vary conſiderably
rding to the proportion and the ingredients made
of.

The effects and theory of aqua regia.

he nature of this mixed acid has not yet been
rly aſcertained. After the diſcovery of the de-
giſticated marine acid, it was concluded, that the
ous acid performed the ſame office as the man-
ſe does; that is, in fact, that it either deprives
marine acid of phlogiſton, or affords vital air to
bine with it, or both. Several difficulties however
oſe this ſuppoſition. If the marine acid be en-
d to calcine and diſſolve gold becauſe it has been
logiſticated or aerated by the nitrous acid, it
ld follow much more ſtrongly that the nitrous acid
f ſhould diſſolve that metal, which is contrary to
fact. And, again, it has not been ſhewn how
dephlogiſticated acid, which is ſo volatile, and ſo
ingly ſoluble in water, is retained in the ſolution:
to mention that no component part of the nitrous
is found to eſcape during the effervefcence, ex-
the vital air which enters into the compoſition of
gas that flies off. When the two acids are in due
ortion, therefore, aqua regia muſt conſiſt of marine
, and nitrous acid which has an under-proportion
tal air, or is in the moſt fuming ſtate; or, in other
ds, it contains the two baſes of the acids, together
vital air, leſs in quantity than they poſſeſſed in
r ſeparated ſtate. But, whether theſe principles
bine and form a compound acid, or in what other
r they may be arranged, has not yet been experi-
tally determined; though the writings of chemiſts
ind with conjectural inferences reſpecting them.

AQUA REGIA.

Combinations.

The combinations of earths and alkalis, and even o metals, with aqua regia, have not been well examine It is not known whether two different kinds of ſal are formed apart from each other, or whether a tripl combination takes place conſiſting of two acids unite to one baſe. It appears however that in ſome caſ the reſult is one entire compound, and in others tw ſeparate ones.

CHAP. IV.

OF FIXED AIR, FIXABLE AIR, OR AERIAL ACID.

FIXED AIR.

Subſtances which contain fixed air.

Page 52—55.

Impregnation of water.

THE acid which is commonly known by the name of fixed air, abounds in great quantities in naure, and appears to be produced in a variety of circumſtances. It compoſes about one third of the weight of limeſtone, marble, calcareous ſpar, and other natural ſpecimens of calcareous earth, from which it may be extricated either by the ſimple application of heat, or by the ſuperior affinity of ſome other acid; moſt acids having a ſtronger action on bodies han this. This laſt proceſs has been before deſcribed. It does not require heat, becauſe fixed air is trongly diſpoſed to aſſume the elaſtic ſtate. Water, under the common preſſure of the atmoſphere, and t a low temperature, abſorbs ſomewhat more than its bulk of fixed air, and then conſtitutes a weak acid. If the preſſure be greater, the abſorption is augmented. Heated water abſorbs leſs; and if water impregnated with this acid be expoſed on a briſk fire, the rapid ſcape of the aerial bubbles affords the appearance of he water being at the point of boiling, when the heat s not greater than the hand can bear. Congelation ſeparates it readily and completely from water; but no degree of cold or preſſure has yet exhibited this acid in a denſe or concentrated ſtate of fluidity.

Fixed air is nearly twice as heavy as common air; and for that reaſon occupies the lower parts of ſuch

FIXED AIR.

mines or caverns as contain materials which afford it by decompoſition. The miners call it choke damp.

Groto del Cano.

The Grotto del Cano, in the kingdom of Naples, has been famous for ages on account of the effects of a ſtratum of fixed air which covers its bottom. It is a cave or hole in the ſide of a mountain near the lake Agnano, meaſuring not more than eighteen feet from its entrance to the inner extremity; where if a dog, or other animal that holds down its head, be thruſt, it is immediately killed by inhaling this noxious fluid.

Fixed air emitted from fermenting bodies.

Fixed air is emitted in large quantities by bodies in the ſtate of the vinous fermentation; and on account of its great weight it does not fly off, but remains in the upper ſpace of the veſſel, not occupied by the fermenting body. A variety of ſtriking experiments may be made in this ſtratum of elaſtic fluid. Lighted paper or a candle dipped into it, is immediately extinguiſhed; and the ſmoke remaining in the fixed air renders its ſurface viſible, which may be thrown into waves by agitation, like water. If a diſh of water be immerſed in this air, and briſkly agitated, it ſoon becomes impregnated, and obtains the lively taſte of Pyrmont water. In conſequence of the weight of the fixed air, it may be dipped out in a pitcher, or bottle; which, if well corked, may be uſed to convey it to great diſtances. The effects produced by pouring this inviſible fluid from one veſſel to another, have a very ſingular appearance: if a candle, or a ſmall animal, be placed in a deep veſſel, the former becomes extinct, and the latter expires, in a few ſeconds after the fixed air is poured upon them, though the eye is incapable of diſtinguiſhing any thing that is poured.

Experiments made in an atmoſphere of fixed air.

When

Converſion of vegetable matter into charcoal.

Production of fixed air from charcoal.

When vegetable ſubſtances are expoſed to a ſtrong at in veſſels partly cloſed, the volatile principles fly ; but combuſtion does not take place for want of . The fixed reſidue is the inflammable ſubſtance led charcoal. For general purpoſes, wood is con- ted into charcoal by building it up in a pyra- dical form, and covering the pile with clay or earth, ving a few air-holes, which are cloſed when the ſs is perfectly lighted; and by that means the com- ſtion is carried on in an imperfect manner. Com- n charcoal, when expoſed to heat in cloſed veſſels, es out a ſmall quantity of inflammable air, which ms extraneous to it; and if it be burned, it leaves mall portion of earth, fixed alkali, and other ſalts. e greater part of charcoal therefore conſiſts of an lammable ſubſtance; and it is found that, if this be rned in a cloſed veſſel over mercury, with vital air, product is fixed air, and nothing elſe; as is proved the reſidue after the fixed air has been abſorbed by ſtic fixed alkali: for there is either no aerial reſi- e, or the reſidue conſiſts of vital air as pure as at t *.

Compoſition of fixed air.

Opinions.

Hence it follows, that fixed air conſiſts of the in- mmable matter of charcoal united to vital air. The iphlogiſtian philoſophers conſider this matter as a culiar combuſtible and acidifiable baſe, and thence er the preſence of charcoal in all caſes where fixed is extricated or produced: but, on the other hand, eral of the phlogiſtians think themſelves juſtifiable concluding that fixed air is produced by the union

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* Lavoiſier in Mem. Acad. Par. for 1781, p. 449.

of inflammable air with vital air, when either of them is in the naſcent ſtate, or ſtate of extrication.

The electric ſpark paſſed through fixed air.

When the electric ſpark * is paſſed through fixed air confined by mercury, the volume of air is augmented about one twenty-fourth part; and of this three fifths are abſorbed by a ſolution of cauſtic alkali, and the remainder is inflammable. An eminent philoſopher of the phlogiſtic opinion ſuppoſes this effect to ariſe from the decompoſition of the fixed air, whoſe vital air, combining more intimately with part of the inflammable air, forms water, the reſidue of this laſt air being diſengaged. But the chemiſt who made the experiment accounts for it as follows, without ſuppoſing the fixed air to be decompoſed :—The air of the atmoſphere, and other elaſtic fluids, are proved by experiment to be capable of retaining mercury in ſolution; ſo likewiſe in all probability does the fixed air: and they all retain much water. Whenever therefore the electric ſpark, by paſſing through this mixture of fixed air, mercury, and water, ignites a minute portion of it, the vital air of the water unites with and calcines the mercury; while the inflammable air of the water is ſet at liberty; and the fixed air, like other acids, unites to the mercurial calx, and falls down with it. He ſuppoſes, from analogy, that the water in the fixed air increaſes its volume by rarefying it; and that th ſubtraction of the water occaſions a contraction, whil

Phlogiſtic explanation.

Antiphlogiſtic explanation.

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* This experiment, firſt performed by Prieſtley, I. 248, h ſince been repeated by Van Marum and others. The experiment of M. Monge, quoted by Kirwan in his Eſſay on Phl giſton, p. 193, ſecond edition, is that ſpoken of in the text: an the opinions are thoſe of Meſſ. Kirwan and Monge.

th

ıe diſengagement of the inflammable air produces a mewhat greater augmentation of bulk. In this way ıppoſing the water and mercury to be preſent in ſuf:ient quantity) the whole of the fixed air may enter to a ſolid combination, and nothing remain but inımmable air. Additional experiments muſt however : made, before either opinion can be eſtabliſhed.

Combinations of fixed air; with clay:

Fixed air does not appear to be ſtrongly diſpoſed to ıite with argillaceous earth. Moſt clays however Ford a ſmall quantity of this fluid by heat; and the ıowy white ſubſtance reſembling chalk, and known y the name of lac lunæ, is found to conſiſt of clay ıturated with fixed air. A ſaline ſubſtance, conſiſtıg of two ſix-ſided pyramids joined at one common aſe, weighing five or ſix grains, and of a taſte ımewhat reſembling alum, was produced by leaving n ounce phial of water, impregnated with fixed air nd a redundancy of earth of alum, expoſed to ſponıneous evaporation for ſome months.

—with calcareous earth:

Calcareous earth and fixed air have a ſtrong attracon for each other. Moſt of the ſpecimens of calıreous earth abound with this acid; and the immeiate precipitation of lime from lime-water is the teſt f the preſence of this acid.

—with ponderous earth:

Ponderous earth combines very ſtrongly with fixed ir. This compound has been found in England; and, ike the foregoing, has already been treated of in the :hapter on earths.

— with magneſia.

Magneſia unites readily to a large proportion of ixed air.

Page 106.

The uſual method of procuring magneſia is, by pre:ipitation from a ſolution of Epſom ſalt, by adding

an

Cryſtallized combination of magneſia with fixed air.

an alkali which combines with the acid. When a mild fixed alkali is uſed, it is neceſſary that the ſaline ſolutions ſhould be boiling hot, and the ebullition continued for a ſhort time, in order to diſſipate a portion of fixed air, which would hold part of the magneſia in ſolution. From this cauſe it is, that perfectly mild vegetable alkali affords no precipitate when added to a ſolution * of Epſom ſalt at the temperature of 60°. The mineral alkali, which contains leſs fixed air than the cryſtallized vegetable alkali, likewiſe affords but a ſmall quantity of precipitate, unleſs heat be applied. Mild volatile alkali alſo poſſeſſes the property of affording no precipitate when added to a ſolution of Epſom ſalt in the cold: with a greater heat magneſia is ſeparated; and at a boiling heat it is again taken up, moſt probably forming a triple ſalt compoſed of vitriolic acid united to volatile alkali and magneſia. The ſaline combination of magneſia and fixed air is ſeparated in cryſtals from all theſe cold ſolutions by ſtanding uncovered; during which time the fixed air, which held the magneſia in ſolution, is no doubt gradually diſſipated. The cryſtals afforded when vegetable alkali is uſed, are contaminated with vitriolated tartar, which ſeparates at the ſame time; thoſe obtained by mineral alkali are finer and purer: but the moſt beautiful and pureſt are obtained by leaving the ſolution to which volatile alkali has been added, expoſed for ſome days in an oblong veſſel.

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* One part Epſom ſalt, diſſolved in ſix parts water, was mixed with one part cryſtallized vegetable alkali, diſſolved in five parts water. Conſult Fourcroy in the Annales de Chimie, II. 282, from whom the whole of this article reſpecting aerated magneſia is taken.

This

Combinations of fixed air:

This cryſtallized aerated magneſia has uſually the rm of ſix-ſided priſms. It is almoſt taſteleſs; efflo- ſces in the air; becomes pulverulent by heat, by e loſs of its fixed air and water; is ſoluble in about rty times its weight of water at the temperature of °. Half its weight conſiſts of fixed air, one fourth ater, and one fourth magneſia; whereas the common rated magneſia obtained by rapid precipitation contains forty parts magneſia, forty-eight fixed air, and elve water.

—with earths:

All the earthy combinations of fixed air are nearly ſoluble in water; they are all more ſoluble with an cceſs of that acid than in mere water; and they all ve out their fixed air by heat, except the native ſpe- men of aerated ponderous earth. This laſt contains o water; and water ſeems to be eſſentially neceſſary enable bodies to aſſume the aerial form.

Fixed air has no action upon ſiliceous earth.

—and with alkalis:

The three alkalis form concrete cryſtallizable ſalts hen united with fixed air, which being in fact neu- al ſalts, are much leſs active than the cauſtic or pure kalis themſelves. Theſe ſalts ſtill continue to be alled the mild alkalis; becauſe the fixed air, though forms a large proportion of their weight, is diſplaced y moſt other acids, and therefore does not obviouſly em to impair their alkaline properties: beſides which, s this volatile acid flies off in the elaſtic form, and s loſt in common experiments (exhibiting no other ndication of its preſence than the violent ebullition hich accompanies its eſcape), it was formerly over- ooked, and even at the preſent time is not always ufficiently attended to.

Alkaline air and fixed air unite, and form the concrete volatile alkali.

Combination of fixed air with combuſtible matter.

The combinations of fixed air with inflammable ſubſtances have not been accurately examined. Metallic calces uſually contain more or leſs of this acid. Plumbago, or black lead, is the moſt remarkable compound into which it enters. This affords much fixed air: but chemiſts are not agreed with reſpect to its combuſtible part; ſome conſidering it as the mere principle of inflammability, and others aſſerting it to be iron.

Advantages derived from a knowledge of this acid.

When we take a retroſpective view of the numerous difficulties in chemical ſcience reſpecting the mild and cauſtic ſtate of lime and alkalis, and their effervеſcence with acids in the one but not the other ſtate; the interrupted effects of affinities; the pernicious effects of caverns, or of places where charcoal is burned, or proceſſes of fermentation are carried on; the nature of medicinal ſprings, and the component parts of a large proportion of mineral as well as organized bodies, which embarraſſed the world before the diſcovery of this acid; we have juſt reaſon to affirm that the name of Dr. Black of Edinburgh would have been immortal, if this had been the only one of the many diſcoveries which he has added to the maſs of human knowledge.

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CHAP. V.

OF THE ACID OF BORAX.

BORAX.

ORAX is a ſalt which comes to us from the Eaſt Indies, and whoſe origin has till lately been dubious. At preſent however it is very well tained * that it is dug up in a cryſtallized ſtate the bottom of certain ſalt lakes in a mountain- barren, volcanic diſtrict, about five-and-twenty journey to the eaſtward of Laſſa, the capital of kingdom of Thibet. Tincal, or crude borax, he ſtate we receive it, is of a dull white or niſh colour, in irregular cryſtals, covered with ncid oily ſubſtance, ſaid to be added to prevent eliqueſcing, and intermixed with earthy impuri- It is not well known in what proportions the onent parts exiſt in the borax when dug out of arth; becauſe it is ſaid to be purified by ſubſe- t ſolution in water and cryſtallization ſoon after mes from the mountains: and the borax of merce is chiefly refined in Holland by a proceſs h is kept a ſecret; though there is little doubt it conſiſts of ſolution, filtration, cryſtallization, calcination, to free it from the impurities and ſe; and afterwards a ſecond ſolution and cryſtal- ion, probably with an addition of mineral alkali, alt of ſoda. M. Chaptal, after trying various

Natural production of tincal or crude borax.

Purification of borax.

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* Phil. Tranſ. Vol. LXXVII. No. 21. 29.

proceſſes

proceſſes in the large way, found the method of calcination to be attended with loſs; and approves o ſtrong and continued boiling with water, and cryſtallization, followed by a ſecond ſolution, ebullition, an cryſtallization, as the ſimpleſt method of purifyin this ſalt *.

Analyſis of borax.

If borax be diſſolved to ſaturation in boiling wate and the vitriolic acid be added in ſuch a quantity as t be perceptibly in exceſs, a ſalt will be diſengaged, during the cooling, in white ſcales, which will ſwim at th ſurface of the fluid. Theſe being taken out, the r maining ſolution affords Glauber's ſalt by evaporatio This laſt ſalt, conſiſting of the vitriolic acid united t mineral alkali, affords a proof that the alkali was o of the component parts of the borax: and when, b adding the diſengaged ſcaly ſalt to mineral alk in a due proportion, borax is reproduced, we have complete proof that the ſcaly ſalt is the other comp nent part. It was originally denominated ſedative ſ but is now known by the name of acid of borax.

The acid of borax may be obtained alſo by ſub mation; the alkaline baſe being ſeparated by the p vious addition of ſome ſtronger acid.

Habitudes of borax:

Borax contains a larger proportion of alkali t is neceſſary to ſaturate the acid. Some of the alk is ſaid to be added in the purification of the tin This purified ſalt requires about eighteen times weight of water to diſſolve it, at the temperature 60°. When heated, it ſwells up, loſes its water cryſtallization, and runs into a kind of glaſs, wh

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* Elements of Chemiſtry, Eng. Tranſlation, I. 277.

BORAX AND ITS ACID.

ay be diſſolved in water, and cryſtallized, as be- re.

— and its acid.

The acid of borax requires about fifty times its ight of water to diſſolve it. In a moderate heat melts with leſs intumeſcence than borax itſelf; and e glaſſy ſubſtance, thus formed, is again ſoluble in ter, having only loſt its water of cryſtallization.

Borax is uſed as a flux in ſoldering, and its acid is a ry uſeful flux for experiments with the blow-pipe.

Native acid of borax.

The acid of borax has been found uncombined in e waters of certain lakes in Tuſcany. There have en ſeveral accounts of the artificial production of rax ſaid to be practiſed in China, and verified by periments made in France; but they all want far- er confirmation.

Hard cryſtallized ſtone containing acid of borax.

It has lately been diſcovered that a cryſtallized ne, found in a cleft near the top of a ſtratified ountain compoſed of plaſter ſtone or gypſum, con- ns a large proportion of the acid of borax *. This ountain, which bears the name of Kalkberg, is ſitu- d near Luneberg in the duchy of Brunſwick; and e ſtone which has been called cubic quartz, but is own to the inhabitants of the vicinity by the name wurfelſtein, is uſually of a white colour, often ey, and ſometimes of a violet tinge. Its figure, hen perfect, appears at firſt ſight to be cubic; t, when attentively inſpected, is found to be com- ſed of twenty-ſix faces. Moſt ſpecimens are opake;

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* See the Annales de Chimie, II. 101 and 137, for examina- ns of this mineral, by M. Weſtrumb and by M. Heyer. The rmer is referred to in the text.

Analyſis of the native combination of the acid of borax with lime and magneſia.

ſome are ſemi-tranſparent, and a few are perfectly tranſparent. The greater number of theſe cryſtals have the appearance of having been corroded. It is evidently of a laminated texture; though its fracture ſeems to exhibit a radiated appearance. Its ſpecific gravity is about 2.566, and its hardneſs is ſuch that it ſcratches glaſs, and gives fire plentifully with the ſteel.

This ſtone loſes its tranſparence by ignition, and becomes pulverable if quenched in water; though the hardneſs of its particles cauſes it to abrade the hardeſt mortars which can be uſed. An extreme degree of heat cauſes it to run into a yellow glaſs. Water does not diſſolve it, either cold or by ebullition. Alkalis act upon it in the dry way, but not readily; and in this operation a conſiderable loſs of weight is experienced. Acids, by long boiling upon the pulverized ſtone, diſſolve it for the moſt part. Five days boilin of marine acid upon one hundred grains of the ſton diſſolved it at laſt.

The ſolution in marine acid firſt exhibited foliate cryſtals at its ſurface, which fell to the bottom; and a the evaporation proceeded, the whole maſs fixed int a yellowiſh white ſubſtance. This was ſoluble i water, and let fall a ſmall portion of ſiliceous earth The ſolution, being examined by the methods of an lyſis hereafter to be deſcribed, afforded a ſmall quantit of iron, with ſome lime; and, by the addition of vitriol acid and ſublimation, the acid of borax was obtaine An additional quantity of this ſubſtance was afford by waſhing the reſidue with the ſtrongeſt ardent ſpiri and evaporating the ſolution till cryſtals were afforde The component parts of the ſtone were thus found

I

BORAX AND ITS ACID.

.cid of borax deprived of its water of cryſtal- n by a red heat, 68 parts; magneſia, 13½; 11; clay, 1; calx of iron, 1; ſilex, 2; loſs in cration, 3½. By adding the mineral alkali to .d thus obtained, a true borax was formed.

Combinations of the acid of borax with earths and alkalis.

acid of borax combines in the humid way ie calcareous, ponderous, and magneſian earths, .o with the alkalis, forming compounds hitherto tle examined. It does not directly diſſolve the in the humid way; but notwithſtanding its affinity, compared with other acids, it is proba- it the combinations might be effected by double r. It diſſolves ſiliceous earth in the dry way. of wine diſſolves it, and burns with a green vhen ſet on fire.

Suppoſed reduction of borax.

attempts have been made to decompoſe this or to exhibit it in the aerial form. Some Ger- iemiſts have lately obtained a metallic ſubſtance ting borax with charcoal in a ſtrong fire, in the reduction. But it is at preſent generally ad- that this metal was iron, from the crucible *.

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* Ruprecht in the Journal de Phyſique for 1790.

CHAP. VI.

OF THE ACID OF SPAR.

ACID OF SPAR.

Fluor or Derbyſhire ſpar.

THE fuſible ſpar, or fluor, which is commo known in England by the name of Derbyſhi ſpar, contains a peculiar acid united to calcareous ear The texture of this compound is either ſparry, irregularly ſhattered or cracked. It is either tran parent or opake; and the ſpecimens are of a cub rhomboidal, polygonal, or irregular figure. The loured ſpars have the property of becoming phoſph reſcent, or emitting light, when laid upon a hot ir or otherwiſe heated; but they loſe this property being made red hot. This ſpar is not ſufficiently ha to ſtrike fire with the ſteel. It is inſoluble in wa and does not effervefce with acids.

Diſtillation of the acid.

If the pure fluor, or ſpar, be placed in a retort lead, with a receiver of the ſame metal adapted, half its weight of vitriolic acid be then poured up it, the acid of ſpar will be diſengaged in the ae form by the application of a gentle heat. This a air readily combines with water; for which purpoſ is neceſſary that the receiver ſhould previouſly be l filled with that fluid. When experiments are requ to be made with the acid in the elaſtic ſtate, it m be received over mercury.

Diſtinctive character.

The diſtinguiſhing property which is moſt eminen and almoſt excluſively, poſſeſſed by this acid, is th diſſolving ſiliceous earth. The firſt experiments u

Siliceous earth diſſolved.

c made with glaſs veſſels, and were attended the ſingular phenomenon of an earthy matter depoſited at the inſtant that the air came in con- ith the water in the recipient. Upon examina- was found to be ſiliceous earth; and ſubſequent ments proved that it was obtained by corroſion glaſs, and held in ſolution by the elaſtic fluid. ircumſtance ſhews the neceſſity of uſing metal- lels in the diſtillation.

Etchings on glaſs.

fluor acid has been ſucceſsfully uſed to make gs on glaſs, in the ſame manner as the nitrous as long been applied to copper.

Combinations with earths and alkalis:

th argillaceous earth it forms a neutral ſalt, of atinous conſiſtence. With calcareous earth it ces the ſpar already treated of. With ponder- arth it forms a ſalt of difficult ſolution, which ſces in the air. It readily combines with mag- and forms a cryſtallizable ſalt; it takes this from every other known acid. With the ve- e alkali it affords a fuſible deliqueſcent ſalt; the n of which, if ſufficiently evaporated, takes a ge- us appearance. The mineral and volatile alkalis id to act nearly in the ſame manner.

—with metals.

is acid acts ſcarcely, if at all, upon gold, ſilver, mercury, tin, antimony, biſmuth, or cobalt, h it diſſolves their calces. It acts directly upon nd zinc, with the production of inflammable air; it likewiſe diſſolves copper in the metallic ſtate, h leſs eaſily than when calcined.

CHAP. VII.

OF THE ACID OF AMBER.

AMBER.

Characters of amber:

AMBER is a hard brittle ſubſtance, ſometi
perfectly tranſparent, but moſtly ſemi-tranſpar
clouded, or opake. It is found of all colours,
chiefly yellow or orange. Some ſpecimens con
inſects or leaves. When broken, it preſents a poli
ſurface at the place of fracture. It is capable o
good poliſh, though always of a ſomewhat greaſy f
By friction it becomes electric, and is the ſubſtanc
which the operation of electricity was firſt taken no
of by the ancients. It emits an agreeable ſmell w
rubbed or heated, and melts at a leſs temperature t
is required to cauſe mercury to boil. With acceſ
air it is inflammable; but by diſtillation in cl
veſſels it affords a ſmall portion of water, a conc
ſublimate which is the acid of amber, and an oil.
gentle heat is ſufficient to raiſe the acid; and care
be taken to regulate it ſo as not to drive up the
when the acid is required to be had in a ſtate of pu
The acid itſelf is ſoluble in twenty-four parts of
water, and in a much leſs quantity when boiling
The ſublimed acid requires to be purified by repe
ſolutions and cryſtallizations.

— where found.

Amber is dug out of the earth in the Pruſſian
minions in greater plenty than elſewhere; but
beſt ſort is taken out of the ſea, or is caſt on
by the waves. From its being found in the

the neighbourhood of foſſil wood, as well as from her circumſtances, it is ſuppoſed to be of vegetable igin. Its analyſis evidently ſhews that it conſiſts an oil rendered concrete by combination with an id.

Combinations of the acid of amber.

The acid of amber combines with the earths, kalis, and metallic calces. With clay it affords a lt in cryſtals; with lime and ponderous earth it oduces ſalts of difficult ſolubility; and with magefia, a compound reſembling gum. With the vegeble and volatile alkalis it forms cryſtallizable ſalts, hich deliqueſce by expoſure to the air; but with the ineral alkali it forms a ſalt whoſe cryſtals are conſtent. With the calces of the metals it forms cryſls which are for the moſt part permanent.

From its ſublimation in the form of flowers, it is vident that it cannot be exhibited in the aeriform tate but at a very elevated temperature. No inquiies have been made in the way of decompoſing it.

CHAP. VIII.

OF PHOSPHORUS AND ITS ACID.

PHOSPHORIC ACID.

Native phoſphorus.

THE phoſphoric acid, or its baſe, abounds in the animal and vegetable, as well as the mineral kingdoms. In this laſt it is found united to lead or iron, but perhaps moſt abundantly in combination with calcareous earth. It is aſſerted that there are whole mountains in Spain which conſiſt of a compound of lime and phoſphoric acid *. But the acid has been hitherto moſt commonly obtained from animal ſubſtances.

Characters of phoſphorus.

Phoſphorus is a ſubſtance greatly reſembling ſulphur in colour and conſiſtence, in its uſual ſtate of purification; but it is leſs brittle, and much more inflammable. When very pure, it is of a clear tranſparent yellow colour. Like ſulphur, it burns with two kinds of flame.

Page 140.

An heat of about 60° produces the weaker kind of flame, which ſcarcely affords any ſenſible degree of warmth. It has the appearance of white fumes in the day light, but is conſiderably luminous in the dark. If a veſſel containing a ſmall piece of phoſphorus be ſurrounded with water gradually heated, the fumes eſcape more and more rapidly; and when the water is heated to 160°, the phoſphorus takes fire, and burns with a ſtrongly vivid and deſtructive flame.

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* Annales de Chimie, I. 196.

This

PHOSPHORUS.

The diſcovery of phoſphorus; by Brandt, Kunckel,

and Boyle.

Defence of Boyle as the inventor.

Proceſs of Boyle.

This ſubſtance, remarkable for its extreme com- ſtibility, and the exhibition of flame without heat, s firſt diſcovered about the year 1667, by a chemiſt oſe name was Brandt. Another chemiſt, well own by his writings, whoſe name was Kunckel, covered the ſecret of Brandt by a ſet of experi- nts expreſsly inſtituted for that purpoſe. It is to s philoſopher that the world has juſtly given the nour of the diſcovery. Our eminent Robert Boyle ewiſe made the diſcovery upon the ſame informa- n probably as that of Kunckel; namely, that phoſphorus was produced from urine. It is aſ- ted that a certain dealer in ſecrets, one Krafft, mmunicated the proceſs to Boyle *; but it is not bable that a man of ſuch undoubted integrity as yle would have communicated the proceſs to the yal Society as his own, if this had been the caſe. ither indeed does the invention appear to be of t magnitude, as not to be eaſily hit upon by thoſe o were determined to ſpare no pains nor attention the purſuit of diſcovery, as was the caſe with the emiſts of that day, moſt of whom indulged extra- gant hopes. The proceſs of Boyle conſiſted in no- ng more than diſtilling urine till the laſt volatile oduct came over, which is the phoſphorus; and uſed no other artifice to facilitate the operation, an that of firſt evaporating the fluid part of the ine until it became of the conſiſtence of ſyrup. He en mixed this liquid with thrice its weight of e ſand, and expoſed the whole to diſtillation for

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* Stahlii CCC. Exper. ed. Berolini, Ann. 1731, p. 393.

twelve

twelve hours, the fire being made as intenſe as poſſible for the laſt ſix hours. Other proceſſes have ſince been invented to ſhorten this operation; but the late diſcovery of Scheele has ſuperſeded them all, on account of its greater expedition and cheapneſs.

Proceſs for obtaining phoſphorus from bones.

The fixed reſidue of bones, after burning, conſiſts of the acid of phoſphorus united to lime. If therefore this white friable ſubſtance be pounded, and paſſed through a ſieve, and a quantity of diluted vitriolic acid be added, leſs than is ſufficient to diſſolve the maſs, it will then conſiſt of a ſolution of ſelenite, with diſengaged phoſphoric acid. By evaporation of the clear liquid, the ſelenite ſeparates in cryſtals and the decanted liquor, by farther evaporation t dryneſs, and the application of a conſiderable hea affords the phoſphoric acid in the form of a whit or tranſparent glaſs. If this acid be pounded, an mixed with one third of its weight of charcoal, in a earthen retort, it affords phoſphorus by diſtillation.

Phoſphoric glaſs.

The phoſphoric glaſs obtained in the firſt inſtanc from bones, is not ſufficiently deprived of calcareou earth to be uſed in any other proceſs than that o making phoſphorus. For this purpoſe however it not neceſſary to bring it to the conſiſtence of glaſ The evaporation may be conveniently performed in copper veſſel; and when the fluid has acquired th conſiſtence of ſyrup, it may be mixed with its ow weight of charcoal in powder, and ſubmitted to diſti lation in a good earthen retort. Inſtead of applyi a receiver, the neck of the retort may be immerſ in a baſon of water to a ſmall depth; and the pho phorus, as it comes over, will fall in drops to t

botto

Proceſs for obtaining phoſphorus.

bottom. It is true that in the proceſs thus managed there will be apparently much phoſphorus burned by the admiſſion of the common air, which now and then paſſes into the neck of the retort, whenever the abſorption of the water cauſes its ſurface to fall below the aperture; but this quantity is really inconſiderable, and is compenſated by the ſimplicity and facility of the proceſs. The operator muſt be careful that the neck of the retort be not plunged to too great a depth; becauſe in this caſe the water would paſs into the body of the retort at the time of abſorption, before the ſurface of the water in the baſon had fallen ſufficiently to admit the air. The phoſphorus comes over as ſoon as the retort is red hot; and when the drops ceaſe, the whole apparatus muſt be ſuffered to cool. It has the form of reddiſh wax, or tallow; and may be preſſed together under the water while it is yet warm. If this be done with the naked hand, great care muſt be taken that no particle ſhall remain ſticking to the hands, or under the nails; as ſuch a particle, by taking fire when brought into the air, might produce very painful and diſagreeable conſequences. It may be moulded into ſticks, by putting the pieces into ſmall conical tubes of glaſs, cloſed at one end, and fixed upright in a piece of wood, the whole being immerſed under water: on heating the water, the phoſphorus will melt, and take the deſired form. The impurities that riſe to the upper ends of the tubes may be cut off when taken out, which muſt not be done till all is cool.

Page 57.

Purification of phoſphorus.

Phoſphorus may be had exceedingly pure by ſtraining it through a leather bag immerſed in hot water;

or,

PHOSPHORIC ACID.

Purification of phoſphorus.

or, which is ſtill better, by diſtilling it a ſecond time with a very gentle heat. The blackiſh colour of phoſphorus is aſcribed to a portion of phoſphoric acid which is mixed with it. This diſappears almoſt entirely by boiling with a ſmall quantity of volatile alkali *; and if the phoſphorus be boiled two or three ſucceſſive times in ardent ſpirit, it becomes perfectly tranſparent, and of a beautiful copal colour, with very little loſs of weight.

Phoſphorus muſt be kept in a bottle of water, to prevent its gradual combuſtion.

Phoſphoric acid, obtained by ſlow combuſtion.

If a number of ſticks of phoſphorus be placed upright in a glaſs funnel, a piece of glaſs tube being previouſly put into the neck of the funnel to prevent their falling through; and if this funnel be then inſerted in the neck of a bottle containing diſtilled water, the phoſphorus will be decompoſed by the ſlow combuſtion, provided it be expoſed to a temperature higher than that of 60°; and the phoſphoric acid will gradually paſs through the funnel into the water. The acid thus obtained contains a portion of phoſphorus; but, by expoſure to the air, this alſo becomes converted into acid: or the ſuperfluous portion of phoſphorus may be burned by cauſing the acid to boil.

Concrete phoſphoric acid.

Page 202.

If the water be evaporated from the phoſphoric acid, it may be converted by heat into a ſolid tranſparent ſubſtance, which differs from that obtained immediately from bones by the vitriolic acid, in attracting the humidity of the air, and its ſolubility in water. It is ſaid however that a ſtronger heat will render

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* Annales de Chimie, I. 234.

it

PHOSPHORIC ACID.

it permanent, and deprive it of acidity; which change moſt probably ariſes from its combining with the earth of the crucible.

Phoſphoric acid; obtained by the action of nitrous acid:

Phoſphorus may likewiſe be converted into phoſphoric acid by treating it with nitrous acid. In this operation a tubulated retort, with a ground ſtopper, muſt be half filled with concentrated nitrous acid, and a gentle heat applied. Small pieces of phoſphorus being then introduced through the tube, will be diſſolved with an effervefcence, which is produced by the eſcape of a large quantity of nitrous air. This addition of phoſphorus muſt be continued until the laſt piece remains undiſſolved. The fire being then raiſed to drive over the laſt portions of nitrous acid, the phoſphoric acid will be found in the retort; partly in the concrete, and partly in the liquid form.

—by vitriolic acid:

Vitriolic acid produces nearly the ſame effect as the nitrous; but, being leſs volatile, it is leſs adapted to the purpoſe.

— by ſtrong combuſtion:

The ſtrong combuſtion of phoſphorus effects a decompoſition nearly complete, and leaves the acid in a dry ſtate.

—by a ſtream of vital air.

Phoſphoric acid is likewiſe produced by paſſing a ſtream of vital air through phoſphorus liquefied in hot water.

Phoſphoric hepar; and air.

Phoſphorus combines with the cauſtic fixed alkalis in a boiling heat, and forms an hepar; during which a peculiar elaſtic fluid is given out, which poſſeſſes the remarkable property of taking fire as ſoon as it communicates with the air of the atmoſphere. This air has evidently the ſame relation to phoſphorus as the common hepatic air has to ſulphur; and, like that,

Page 138.

that, it probably conſiſts of a ſolution of the phoſphorus in inflammable air.

Combination of phoſphorus with ſulphur:

— with oils:

—ardent ſpirits:

— metals.

Sulphur and phoſphorus unite by fuſion, and form a ſolid compound of a fetid ſmell, which burns with a yellow flame, and ſwells in water; at the ſame time communicating acidity to that fluid, and emitting a ſmell of hepatic air. All kinds of oils diſſolve phoſphorus, and are rendered luminous by it: ſeveral eſſential oils form a ſolution which takes fire by expoſure to the air, probably in conſequence of the emiſſion of phoſphoric air. The butter of wax, which conſiſts of wax deprived of part of its acid by diſtillation, is ſaid to be the propereſt material for producing this effect. Very ſtrong ardent ſpirit diſſolves a ſmall portion of phoſphorus, which gives a perceptible light upon the addition of water. Metals do not readily combine with this ſubſtance when ſimply heated with it: but when the phoſphoric acid, together with charcoal, is expoſed to a ſtrong heat, a conſiderable number of the metals may be made to unite with it *, probably in conſequence of their being previouſly calcined by the acid.

Metals revived by phoſphorus.

When a ſtick of phoſphorus is plunged in the ſolutions of gold, ſilver, copper, and other metals, the phoſphorus becomes gradually covered with a brilliant metallic ſheath, the phoſphorus becoming acidified as the metal is revived.

Uſes of phoſphorus.

Phoſphorus has not yet been applied to any uſe, excepting that a few trials have been made of its efficacy in medicine. The luminous appearance of

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* Journal de Phyſique, for March 1789.

ing made of a ſtick of phoſphorus upon paper, ny other ſubſtance which can abrade it, is ſuffi- :ly known. There is ſome danger of its catching if the friction be ſwift or violent; and for that n the ſtick of phoſphorus ought to be held in :tallic caſe, and a cup of water ſhould be at hand lunge it in. It is alſo uſed when diſſolved in :tial oils, or butter of wax, to make tapers or :hes, intended to ſupply the place of flint and ſteel roducing light; but it is not probable that theſe ever be afforded ſufficiently cheap to anſwer the oſe of a ſubſtitute to that operation.

Phoſphoric matches.

Two ſtates of phoſphoric acid.

he acid of phoſphorus exiſts, as has been already rved, in two ſtates ſimilar to thoſe of the volatile fixed vitriolic acids: and the difference between : ſtates ariſes likewiſe from a ſimilar cauſe; name- that a part of the phoſphorus is not converted acid, but is held in ſolution by that part which :idified. Neither of the kinds of phoſphoric acid totally by heat like the volatile vitriolic acid: that which contains phoſphorus emits white fumes, :h ſeem to conſiſt of part of the acid combined the redundant phoſphorus; and the reſidue melts the vitreous form. This difference between the olic and phoſphoric acids depends no doubt upon greater degree of fixity of the latter.

Page 140. 148.

Combinations of phoſphoric acid.

he phoſphoric acid does not appear to act upon eous earth, though it corrodes glaſs when hot. It tes with clay in the dry way. With calcareous :h it forms a combination ſcarcely ſoluble in water, :ſs there be an exceſs of acid: it has been already iced that the earthy reſidue of bones conſiſts of this

this ſubſtance. With ponderous earth it forms a ſal whoſe properties are little known; and with magneſi it forms a cryſtallizable compound of difficult ſolubility.

Combinations of phoſphoric acid with alkalis.

This acid, when in combination with the vegetabl alkali, forms a very ſoluble ſalt, which is ſuſpende in conſiderably greater quantity in hot than in col water. It ſeparates from the liquid in cryſtals, eithe by cooling or evaporation. The combination of phoſ phoric acid with mineral alkali conſtitutes a ſalt o an agreeable taſte, reſembling that of common ſal It is not eaſily cryſtallized, by reaſon of its diſpoſ tion to form an adheſive matter by evaporatio which reſembles gum. A ſmall exceſs of alkali re ders it more diſpoſed to cryſtallize, and cauſes it effloreſce by expoſure to the air. This ſalt has bee lately introduced into medicine. The combination volatile alkali with phoſphoric acid is likewiſe mo ſoluble in hot than in cold water, and affords cryſta by cooling. An exceſs of alkali renders the cryſta lization more eaſy. It is greatly diſpoſed to fly off a gentle heat.

Phoſphoric ſalts from urine.

The phoſphoric ſalts were firſt obtained from urin This animal fluid conſiſts of a large quantity of w ter; the acids of phoſphorus and of the calculus the bladder, both in a diſengaged ſtate; ſome comm ſalt, with the ſaline combinations of the phoſpho acid with lime, mineral alkali, and volatile alkali; a two kinds of extractive matter, one of which is ſo ble in ardent ſpirit, and the other in water. Wl urine is expoſed to evaporation by heat, it aſſume darker colour; and a pulverulent matter falls do

wh

nly aſſuming the elaſtic ſtate, cauſed the exploſion; hile the vital air of the calx united with the inflam- able air of the alkali, and formed the water.

Theory.

This ſatisfactory theory was ſtill further confirmed that decompoſition of fulminating gold, which takes ace in conſequence of the action of the concentrated triolic acid, of melted ſulphur, fat oils, and ether; l which deprived it of its fulminating quality by mbining with its volatile alkali.

Precipitation of gold by liver of ſulphur:

Liver of ſulphur precipitates gold from its ſolvent; e alkali uniting with the acid, and the gold falling own, combined with the ſulphur; of which however it may be deprived by moderate heat.

— by metallic ſubſtances.

Moſt metallic ſubſtances precipitate gold from aqua gia; lead, iron, and ſilver precipitate it of a deep d dull purple colour; copper and iron throw it wn in its metallic ſtate; biſmuth, zinc, and mer- ry, likewiſe precipitate it. A plate of tin immerſed a ſolution of gold affords a purple powder, called the purple powder of Caſſius," which is uſed to int in enamel. There are various methods of anaging this proceſs.

Proceſs for making the purple powder of Caſſius.

That deſcribed by Macquer nſiſts in diſſolving tin by very ſmall portions at a ne without heat, in an aqua regia compoſed of o parts of nitrous, and one of marine acid, pre- ouſly weakened with water equal in weight to both e acids. The firſt ſmall portion of tin muſt be ffered to be entirely diſſolved before a ſecond is lded. This addition muſt be continued till the acid s acquired a yellow colour, and ſcarcely acts at all on the tin laſt added.

GOLD.

Proceſs for making the purple powder of Caſſius.

On the other hand, the pureſt gold muſt be diſſolved in an aqua regia, compoſed of three parts of nitrous, and one of marine acid. This ſolution may be made as expeditiouſly as the operator chooſes by the aſſiſtance of the heat of a ſand bath.

The ſolution of tin muſt then be largely diluted; as, for example, with one hundred parts of diſtilled water; and a ſmall quantity of this may then be aſſayed by ſeparating it into two parts, and diluting one of the parts ſtill farther. Upon trial of both, by letting fall a drop of the ſolution of gold into each, it will be ſeen which affords the moſt beautiful purple precipitate. The whole of the ſolution of tin muſt accordingly be altered, if neceſſary, by adding more water. Pour into this ſolution, in a large glaſs or earthen veſſel, nearly half as much of the ſolution of gold as it contains of ſolution of tin, ſtirring the mixture with a glaſs ſtick. In a ſhort time the liquor will become of a beautiful red colour, which wil gradually diſappear by the ſubſidence of the precipitate. By adding a ſmall quantity of ſolution of tin it will be ſeen whether the whole of the gold is precipitated. The clear liquor muſt then be decanted and the precipitate waſhed. It conſiſts of the calce of gold and tin in combination, and is the onl known ſubſtance which has the property of communicating a purple colour to glaſs.

Obſervations.

The difficulties attending the preparation of th article appear to depend on the ſtate of the tin. the ſolution of this metal be made with heat an rapidity, it becomes too much calcined to adhere acid, or to precipitate the gold; and the combi- on of the two metals which falls down, varies in ur accordingly as this term is approached. Theſe the chief circumſtances; but there is no doubt a complete examination of the proceſs would cate others worthy of notice.

Solutions of gold in ether, &c.

ther, naptha, and eſſential oils, take gold from its ent, and form liquors which have been called ble gold. The gold which is precipitated by oration of theſe fluids, or by the addition of tial vitriol to the ſolution of gold, is of the utmoſt ty.

Gold reſiſts nitre:

n the dry way, gold reſiſts the action of neutral , more eſpecially nitre, which deflagrates with imperfect metals. Nitre however does not afford expeditious way of purifying gold, becauſe this l in ſome meaſure protects and covers the alloys its action. It is remarked that borax, uſed as x with gold, renders it paler; and that this al- ion of colour diſappears by the addition of nitre, ommon ſalt. As the acid of borax forms a com- nd with gold, which falls to the bottom when this is added to the metal in ſolution, it is probable the paleneſs produced by borax may ariſe from combination of a ſmall portion of its acid with gold, which might be driven off by a continu- e of the heat; and unites by ſtronger affinity with alkali of the nitre, or of the common ſalt, in portion as their acids are diſſipated by heat.

—but is rendered pale by borax:

—unchanged by earths, alkalis, or ſulphur.

arths and alkalis do not act on gold in the dry . Sulphur, which combines with moſt metals, no effect on this. A proceſs called dry parting is

Proceſs of dry parting.

is grounded on this property, and is more eſpecially uſed in ſeparating ſilver from gold, when the quantity of this latter metal is too ſmall to anſwer the charges of diſſolving the larger maſs of ſilver in nitrous acid. For this purpoſe, the mixed metal is fuſed, and flowers of ſulphur thrown on its ſurface. This combines with the ſilver in the form of a black ſcoria; while the gold remains at the bottom in its metallic ſtate. The operation of dry parting does not leave the gold in a ſtate of purity; becauſe the laſt portions of ſilver ar defended from the action of the ſulphur. But whe the quantity of ſilver is thus diminiſhed, the operatio of parting with aqua fortis, or nitrous acid, may b advantageouſly uſed.

Combination with liver of ſulphur:

Liver of ſulphur diſſolves gold in the dry wa Equal parts of ſulphur and vegetable alkali are to b haſtily fuſed with one fourth of a part of gold lea This combination is ſoluble in water, with which forms a yellowiſh green ſolution. By the addition an acid the gold is thrown down in combinati with the ſulphur; of which it may be deprived heat.

— with metals.

Moſt metals unite with gold by fuſion. With ſi ver it forms a compound, which is paler in propo tion to the quantity of ſilver added. It is remarka that a certain proportion, for example a fifth pa renders it greeniſh. From this circumſtance, as w as from that of a conſiderable proportion of th metals ſeparating from each other by fuſion, in co ſequence of their different ſpecific gravities, wh their proportions do not greatly differ, it ſhould ſe that their union is little more than a mere mixtu

with

ithout combination. For as gold leaf tranſmits the reen rays of light, it will eaſily follow, that par- les of ſilver, enveloped in particles of gold, will fiect a green inſtead of a white light.

Combinations with metals. Platina.

A ſtrong heat is neceſſary to combine platina with ld; it greatly alters the colour of the gold if its eight exceed the forty-ſeventh part of the maſs: it es not much affect the ductility. The Spaniſh iniſtry has prohibited the exportation of platina from merica, leſt it ſhould be uſed in adulterating gold; it this does not appear to be a danger which need be ared, as chemiſtry has long been in poſſeſſion of veral ſimple and expeditious methods of diſtinguiſh- g this fraud, which beſides is evident to the ſight hen the quantity of debaſement is conſiderable. It ay be queſtioned, likewiſe, whether the value of atina would not ſoon exceed that of gold, if its operties and uſes were better known in ſociety.

Vide p. 227, and alſo chap. iii. of this ſection.

Mercury:

Mercury is ſtrongly diſpoſed to unite with gold in proportions, with which it forms an amalgam: is, like other amalgam[b] is ſofter, the larger the oportion of mercury. It ſoftens and liquefies by at, and cryſtallizes by cooling.

—lead, copper, &c.

Lead unites with gold, and conſiderably impairs ductility. Copper renders gold leſs ductile, harder, ore fuſible, and of a deeper colour. This is the ual addition in coin, and other articles uſed in ſo- ety. Tin renders it brittle in proportion to its quan- ty; but it is a common error of chemical writers ſay that the ſlighteſt addition is ſufficient for this rpoſe. With iron it forms a grey mixture, which eys the magnet. This metal is very hard, and is

Alchorne in Phil. Tranſ. vol. 75.

Combinations with metals.

ſaid to be much ſuperior to ſteel for the fabricatio cutting inſtruments. Biſmuth renders gold white an brittle; as do likewiſe nickel, arſenic, and antimon Zinc produces the ſame effect; and, when equal i weight to the gold, a metal of a fine grain is pr duced, which is ſaid to be well adapted to form t mirrors of reflecting teleſcopes, on account of t fine poliſh it is ſuſceptible of, and its not being ſu ject to tarniſh. The alloys of gold with the regul of manganeſe or molybdena are not known. It cou not be mixed with the regulus of wolfram, on accou of the infuſibility of this laſt ſubſtance.

Native ores, or alloys of gold.

Gold is found moſtly in the metallic ſtate, thou generally alloyed with ſilver, copper, iron, or three. It is found either in ſeparate lumps, or vi grains, among the ſands of rivers in many parts Europe, and elſewhere. The quantity is for the m part inſufficient to pay the coſt of ſeparating it; it is thought to be more univerſally diffuſed in ſa and earths than any other metal, except iron. T greateſt quantity of gold is imported into Europe fr South America. Some is brought from the E Indian iſlands and China, and ſome from the co of Africa. The principal gold mines in Europe

Purification.

thoſe of Hungary. Some ſands afford gold by ſim waſhing; the heavy metallic particles ſubſiding ſoon but when it is bedded in earths or ſtones, theſe ſ ſtances are pounded, and boiled with one tenth their weight of mercury, together with water. mercury, after a certain time, abſorbs the gold, may be ſeparated by preſſure through leathern b and ſubſequent diſtillation. Or otherwiſe, if

Auriferous ſands

ınd be heated red hot, and quenched in water ſeve-
ıl times, for the purpoſe of cracking and dividing
, and the whole be then melted into glaſs, with
vice its weight of the calx of lead, called litharge,
ıd charcoal powder be then added, the lead will be
vived into the metallic ſtate, and will carry the gold
ong with it. By expoſure to a proper degree of
eat, with acceſs of air, the lead may again be con-
erted into litharge, and the gold will be left pure.
his laſt operation is in fact a method of aſſaying
nds which contain gold, rather than of obtaining
from them in the large way.

Pyrites containing gold.

Gold is alſo found in certain martial pyrites in
weden and elſewhere; from which it may be ex-
acted by torrefaction, or burning of the ſulphur,
ıd ſubſequent digeſtion in aqua regia.

Cupellation of gold.

To obtain gold in a ſtate of purity, or to aſcertain
ıe quantity of alloy it may contain, it is expoſed
a ſtrong heat, together with lead, in a porous
ucible. This operation is called cupellation, and
performed as follows: The precious metal is put,
gether with a due proportion of lead, into a ſhallow
rucible made of burned bones, called a cupel; and
ıe fuſion of the metals is effected by expoſing them
a conſiderable heat in a muffel, or ſmall earthen
ven, fixed in the midſt of a furnace. The lead
ontinually vitrifies, or becomes converted into a
laſſy calx, which diſſolves all the imperfect metals.
his fluid glaſs, with its contents, ſoaks into the
upel, and leaves the precious metal in a ſtate of
urity. During the cupellation, the ſcoriæ running
own on all ſides of the metallic maſs, produce an

appearance called circulation; by which the operator judges whether the proceſs is going on well. When the metal is nearly pure, certain priſmatic colours flaſh ſuddenly acroſs the ſurface of the globule, which ſoon afterward appears very brilliant and clean: this is called the brightening, and ſhews that the ſeparation is ended.

Separation of gold from the perfect metals: —by quartation: —and parting.

After gold has paſſed the cupel, it may ſtill contain either of the other perfect metals, platina or ſilver. The former is ſeldom ſuſpected; the latter is ſeparated by the operations called quartation and parting. Quartation conſiſts in adding three parts of ſilver to the ſuppoſed gold, and fuſing them together; by which means the gold becomes one fourth of the maſs only. The intention of this is to ſeparate the particles of gold from each other, ſo that they may not cover and defend the ſilver from the action of the pure nitrous acid, which is to be uſed in the proceſs of parting. Parting conſiſts in expoſing the maſs, previouſly hammered, or rolled out thin, to the action of boiling aqua fortis of a due ſtrength. If the acid be not too concentrated, it diſſolves the ſilver, and leaves the gold in a porous maſs of the original form; but, if too ſtrong, the gold is in a powdery form, which may be waſhed and dried. The weight of the original metal before cupellation, and after all the ſubſequent ſtages, ſerves to aſcertain the degree of fineneſs of the ingot, or ore, of which it was a part.

Fineneſs of gold.

The quantity of alloy is never conſidered as part of the value of metals which contain either gold or ſilver. In eſtimating or expreſſing the fineneſs of gold, the whole maſs ſpoken of is ſuppoſed to weigh twenty-

four

ır carats of twelve grains each, either real or rely proportional, like the aſſayer's weights; and pure gold is called fine. Thus, if gold be ſaid be 23 carats fine, it is to be underſtood, that in a ſs weighing 24 carats the quantity of pure gold ounts to 23 carats.

The aſſay of ſmall work, by the touch.

In ſuch ſmall works as cannot be aſſayed by ſcrap- off a part and cupelling it, the aſſayers endeavour aſcertain its quality, or fineneſs, by the touch. This ı method of comparing the colour and other pro- rties of a minute portion of the metal with thoſe certain ſmall bars whoſe compoſition is known. eſe bars are called touch-needles; and they are bed upon the black baſaltes, which for that reaſon alled the touchſtone. Black flint, or pottery, will ve the ſame purpoſe. Sets of golden needles may ıſiſt of—pure gold; pure gold $23\frac{1}{2}$ carats, with half arat ſilver; 23 carats gold, with one carat ſilver; $\frac{1}{2}$ carats gold, with $1\frac{1}{2}$ carat ſilver; and ſo forth, the ſilver amounts to four carats; after which additions may proceed by whole carats. Other dles may be made in the ſame manner, with cop- inſtead of ſilver; and other ſets may have the lition conſiſting either of equal parts ſilver and per, or ſuch proportions as the occaſions of buſi- s require.

Touch-needles.

Obſervations on the aſſay by the touch.

In foreign countries, where trinkets and ſmall work required to be ſubmitted to the aſſay of the touch, variety of needles are neceſſary; but they are not ıch uſed in England. They afford however a de- e of information which is more conſiderable than ght at firſt be expected. The attentive aſſayer

Aſſay by the touch.

not only compares the colour of the ſtroke made upon the touchſtone by the metal under examination with that produced by his needle, but will likewiſe attend to the ſenſation of roughneſs, dryneſs, ſmoothneſs or greaſineſs, which the texture of the rubbed metal excites when abraded by the ſtone. When two ſtroke perfectly alike in colour are made upon the ſtone, h may then wet them with aqua fortis, which will affec them very differently if they be not ſimilar compo ſitions: or the ſtone itſelf may be made red-hot b the fire, or by the blow-pipe, if thin black potter be uſed; in which caſe the phenomena of calcin tion will differ according to the nature and quanti of the alloy.

Aſſay of gold ores in the moiſt way.

Gold ores may be aſſayed in the moiſt way b pounding them very fine, weighing a determina portion, and attempting their ſolution in nitrous aci which will diſſolve the matrix if it conſiſt of calc reous earth; or, if it be ſelenite, the powder may digeſted in aqua regia as long as any metallic ſu ſtance is taken up; after which the gold may precipitated by an addition of vitriol of iron, whi will cauſe it to fall down in the metallic ſtate.

Uſes of gold.

The principal uſe of gold is as the medium exchange in coin; for which it has been choſen occupy the firſt place, on account of its ſcarcity, great weight, and its not being ſubject to tarni The gold coins of Great Britain contain eleven pa of gold, and one of copper.

Gold is likewiſe uſed in gilding; for which purpo as we have already ſhewn, it is mechanically divid into leaves of extreme thinneſs. Theſe are ſtuck up

wo

Water-gilding.

ood, previouſly ſmeared with adheſive oil, or animal ue, called ſize. The proceſs called water-gilding, hich is uſually applied to copper or braſs, is perrmed by immerſing the clean copper into a diluted ution of mercury. The copper is corroded by the id, which at the ſame time depoſits a thin coating mercury. This coating, after the piece is waſhed, cilitates the adheſion of an amalgam of gold, which then to be rubbed upon it. The mercury is afterrds volatilized by heat; and the work is finiſhed by rning gilding wax upon it, which is a compoſition red bole, verdigriſe, alum, and bees wax. The tention of this laſt application appears to be that of ncealing the defects of the gilding.

There is another method of gilding, which is perrmed by ſteeping linen rags in a ſolution of gold, heſe are afterwards dried and burned to aſhes, which ntain gold in a very divided ſtate. Nothing more neceſſary than to moiſten the end of a cork, and p it in this burned matter, together with a little ood aſhes, and rub it upon the face of the ſilver innded to be gilded. By this means the gold eaſily heres.

The other uſes of gold, in laces, &c. are ſufficiently own.

CHAP.

CHAP. II.

CONCERNING SILVER.

SILVER.

Characters of ſilver.

SILVER is the whiteſt of all metals, conſiderably harder than gold, very ductile and malleable, but leſs malleable than gold; for the continuity of its parts begins to break when it is hammered out int leaves of about the hundred and ſixty thouſandt of an inch thick, which is more than one thir thicker than gold leaf: in this ſtate it does not tranſ mit the light. Its ſpecific gravity is moderate, be ing inferior to platina, gold, mercury, and lead. I ignites before melting, and requires a ſtrong heat t fuſe it. The heat of common furnaces is inſufficien to calcine it; but the heat of the moſt powerf burning lenſes vitrifies a portion of it, and cauſes i to emit fumes; which, when received on a plate o gold, are found to be ſilver in the metallic ſtat It has likewiſe been partly calcined by twenty ſu ceſſive expoſures to the heat of the porcelain furnac at Sêves. The air alters it very little; though it diſpoſed to obtain a thin purple or black coatin from the ſulphureous vapours which are emitted fro animal ſubſtances, drains, or putrefying matters. Th coating, after a long ſeries of years, has been obſerv to ſcale off from images of ſilver expoſed in churche and was found, on examination, to conſiſt of ſilv united with ſulphur.

Silv

Solubility of ſilver in acids.

ilver is ſoluble in the vitriolic acid when concen- ed and boiling, and the metal in a ſtate of divi- ı. The marine acid ſcarcely acts upon it, unleſs hlogiſticated: but the nitrous acid diſſolves it with at rapidity, and with a plentiful diſengagement nitrous air; which, during its extrication, gives lue or green colour to the acid, that entirely diſ- ears if the ſilver made uſe of be pure: if it con- copper, the ſolution remains greeniſh; and if acid contain either vitriolic or marine acid, theſe nbine with a portion of the ſilver, and form rcely ſoluble compounds, which fall to the bot- n. If the ſilver contain gold, this metal ſeparates blackiſh coloured flocks. The nitrous acid diſ- ves more than half its weight of ſilver; and the ution is very cauſtic, that is to ſay, it deſtroys and rodes animal ſubſtances very powerfully. This ion appears to depend on the ſtrong diſpoſition the ſilver to become revived; by which it either racts phlogiſton from thoſe ſubſtances according the ancient theory, or communicates vital air to m according to the new theory: ſo that the imal ſubſtances undergo a proceſs equivalent to nbuſtion.

Combination with nitrous acid.

The ſolution of ſilver, when fully ſaturated, depo- thin cryſtals as it cools, and alſo by evaporation. ieſe are called lunar nitre, or nitre of ſilver. A ntle heat is ſufficient to fuſe them, and drive off eir water of cryſtallization. In this ſituation it is a black colour, may be caſt into ſmall ſticks in a ould, and then forms the lapis infernalis, or lunar uſtic, uſed in ſurgery. A ſtronger heat decompoſes lunar

lunar nitre, the acid flying off, and the ſilver remaining pure. It is obvious that, for the purpoſe of forming the lunar cauſtic, it is not neceſſary to ſuffer th ſalt to cryſtallize, but that it may be made by evaporating the ſolution of ſilver at once to dryneſs; an as ſoon as the ſalt is fuſed, and ceaſes to boil, it ma be poured out. The nitrous acid driven off fro lunar nitre is decompoſed, the products being vit air and phlogiſticated air.

Lunar cauſtic.

Page 167, 168.

Although the nitrous acid diſſolves ſilver with ſuc great facility, it appears to do this only in conſequenc of its great power to calcine the metal; for the v triolic and marine acids have a greater attraction f the calx. They accordingly take it from that aci and form ſalts; which, as we have already obſerve fall to the bottom on account of their difficult ſol bility. The vitriol of ſilver, which is formed b pouring vitriolic acid into the nitrous ſolution of ſi ver, is ſparingly ſoluble in water; and on that accou forms cryſtals, which are ſo ſmall that they compo a white powder. The marine acid precipitates fro nitrous acid the ſaline compound called luna corne or horn ſilver, which has been ſo diſtinguiſhed b cauſe, when melted and cooled, it forms a ſemi-tran parent and partly flexible maſs reſembling horn. is ſuppoſed that a preparation of this kind has give riſe to the accounts of malleable glaſs.

Vitriol of ſilver.

Luna cornea.

Malleable glaſs.

If any ſalt with baſe of alkali, containing the m rine acid, be added to the nitrous ſolution of ſilve the ſame effect takes place by double affinity; the alk line baſe uniting with the nitrous acid, and the ſilv alling down in combination with the marine acid.

Sin

Very pure ſilver obtained from luna cornea.

ince the marine acid throws down only ſilver, lead, mercury, and the latter of theſe two are not pre- in ſilver that has paſſed cupellation, though a ll quantity of copper may elude the ſcorification hat proceſs, the ſilver which may be revived from ı cornea is purer than can readily be obtain- y any other means. When this ſalt is expoſed ı low red heat, its acid is not expelled; and a ter heat cauſes the whole concrete either to riſe umes, or to paſs through the pores of the veſſel. reduce it, therefore, it is neceſſary that it ſhould riturated with its own weight of fixed alkali and ttle water, and the whole afterwards expoſed to t in a crucible whoſe bottom is covered with mi- il alkali; the maſs of luna cornea being likewiſe ered with the ſame ſubſtance. In this way the will be ſeparated from the ſilver, which is reduced ts metallic ſtate.

Teſt of marine acid in waters.

s the precipitate of luna cornea is very percep- , the nitrous ſolution of ſilver is uſed as a teſt he preſence of marine acid in waters; for a drop this ſolution poured into ſuch waters will cauſe a y evident cloudineſs. The ſolution of ſilver is alſo

Purification of nitrous acid.

d by aſſayers to purify the nitrous acid from any ixture of marine acid. In this ſtate they call it cipitated aqua fórtis.

Precipitates.

he precipitates of ſilver which are formed by addition of alkalis or earths, are all reducible by re heat, without the addition of any combuſtible ſtance. The fulminating combination of volatile ali with ſilver, exhibits one of the moſt aſtoniſhing inſtances

SILVER.

Preparation of fulminating ſilver.

inſtances of chemical detonation hitherto known*. Pure ſilver is diſſolved in pale nitrous acid, and precipitated by the addition of lime-water. This calx or precipitate, after decantation of the fluid, is t be dried by expoſure to the air for three days. Th inventor thinks the preſence of light has ſome influence in the ſucceſs of the experiment. The drie calx being agitated or ſtirred in a ſolution of cauſti volatile alkali, aſſumes the form of a black powder from which the fluid is to be decanted, and the blac ſubſtance left to dry in the air. This is the fulminating ſilver.

Its effects.

Gunpowder and fulminating gold are not to b compared with this new product; as the former r quires ignition, and the latter a ſenſible degree heat, to cauſe them to fulminate. But the ſlighte agitation or friction is ſufficient to cauſe the fulm nating ſilver to explode. When it is once obtaine it can no more be touched. The falling of a fe atoms of this preparation from a ſmall height pr duced the detonation; a drop of water falling upon had the ſame effect. No attempts therefore can made to incloſe it in a bottle; but it muſt remain the capſule wherein, by evaporation, it obtained th terrible property.

Precautions.

To make this experiment with ſafety, it is prop to uſe no greater quantity than a grain of ſilver; t laſt deſiccation ſhould be made in a metallic veſſ and the face of the operator ſhould be defended

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* Diſcovered by Berthollet. See the Journal de Phyſique June 1788, p. 474.

a m

Salts from urine.

Microcoſmic ſalt.

Perlate acid.

ich conſiſts of the calcareous phoſphoric ſalt, and acid of the human calculus. If the urine be fil- d as ſoon as it has acquired a viſcid conſiſtence, fords ſaline cryſtals by cooling. Theſe conſiſt of common ſalt, and alſo of a triple combination of ſphoric acid with the mineral and vegetable alkalis, ch is generally known by the name of microcoſ- ſalt. Repeated evaporations and coolings are ired to deprive urine of the moſt part of its ſalts. equent ſolution in water, heated and cooled in d veſſels, purifies the phoſphoric cryſtals, and rates the ſalt with the baſe of volatile alkali from which contains mineral alkali. As the former of ſalts only is decompoſed by heating with char- it is from this alone that the phoſphorus of urine tained. The combination of mineral alkali with horic acid was for ſome time ſuppoſed to be a liar acid, and was called the perlate acid.

ıc microcoſmic ſalt has been applied to great uſe ıe celebrated Bergman, as a flux in blow-pipe iments.

Combinations of phoſphoric acid with metals and oils.

oſphoric acid unites with ſeveral of the metallic s. It acts upon oils, to ſome of which it com- cates a peculiar flavour, and it thickens others. not been well decided whether it can be exhi- in the elaſtic ſtate at the temperature of the ſphere.

ıe ſaline compounds formed by the phoſphoric when not totally acidified, appear to differ from of the complete acid; but few experiments have made with theſe.

Theory.

e theory of the converſion of phoſphorus into

P an

PHOSPHORIC ACID.

Theory.

an acid, and the reduction into its original ſtate b treatment with charcoal, is perfectly ſimilar to that o ſulphur and vitriolic acid. When phoſphorus burned, there is an abſorption of vital air, at the ſam time that phlogiſton, or the principle of inflammabi lity, is ſuppoſed to be extricated. In this manner th phoſphorus is converted into an acid, which, whe water is not preſent, has the appearance of whi flakes; and in every ſtate weighs conſiderably mo than the phoſphorus itſelf. On the other hand, whe phoſphoric acid is heated with charcoal, the vital air abſorbed by the latter; at the ſame time that phoſphoric baſis is ſuppoſed to receive phlogiſton fro the charcoal, and by that means recovers its origi ſtate. According to the new theory, the phoſpho is conſidered as a ſimple ſubſtance, relatively to preſent ſtate of our knowledge; its converſion into acid being ſuppoſed to conſiſt merely in the abſorpt of vital air, and its revivification in the diſengagem of that ſubſtance.

CHAP. IX.

OF THE METALLIC ACIDS; OF ARSENIC, OF MOLYBDENA, AND OF TUNGSTEN, OR WOLFRAM.

ACIDITY.

Retroſpect of the facts and doctrines contained in the preſent ſection.

IN the preceding chapters we have exhibited a number of inſtances in which the proceſs of com- uſtion has converted inflammable ſubſtances into cids: whence it may be inferred, as a general rule, hat acidity is the ſtate of a combuſtible body, which burned, either completely or nearly ſo; whether ich combuſtion be made to conſiſt in the diſengage- ient of phlogiſton and abſorption of pure air, or hether it be ſtated ſimply as the latter effect. We ive ſeen that ſulphur, which is highly inflammable, comes converted into vitriolic acid air, which is not all inflammable; and that, when completely burned, becomes vitriolic acid, in which the peculiar pro- rties of that claſs of bodies are moſt eminently en. Phlogiſticated air, which, by reaſon of its ſlight ndency to unite with vital air, appears to require her a long expoſure to that ſubſtance, or the ſucceſ- e ignition of its parts by electricity, is found to form trous air when the combuſtion is incomplete—a bſtance which has no acid properties; but which be- mes nitrous acid of various degrees of acidity, ac- rding to the doſe of vital air it may be combined th, and perhaps the extrication of phlogiſton. The tals have been ſhewn to be combuſtible, as well by

the

Acidification of metals.

the action of acids, as by heating them with acceſs of pure air. When they are thus calcined they become ſoluble in acids. Some of the metallic bodies have been diſcovered to be ſuſceptible of a farther continuation of the proceſs by which they are calcined; and this continuation is found to change them into acids ſoluble in water, and diſpoſed to combine with and neutralize alkaline ſubſtances. Hence there ſeem to be certain periods of combuſtion at which the ſame ſimple baſis becomes ſucceſſively converted into a calx, or ſubſtance capable of neutralizing acids; and afterwards into one which combines with and neutralizes alkalis.

General inferences; by conjecture.

If we might generalize this, it would be fair to conclude that all metals are, in their own nature, capable of being converted into acids; that all acids are reducible to inflammable ſubſtances, though art has not yet deviſed the means of doing it in every inſtance; and it might be conjectured that the fixed alkalis themſelves may conſiſt of combinations of inflammable ſubſtances with pure air, to which they may adhere with too ſtrong an affinity to be ſeparated by means of any medium we are acquainted with.

Metals acidified.

The metallic ſubſtances which have been acidified are, arſenic, molybdena, and wolfram.

Arſenic.

Arſenic is a ſubſtance which combines with an mineralizes many of the metals, and is ſublimed from them in the form of a white calx. It is not clearl aſcertained, in a number of inſtances, whether th metals be combined with this calx, or with the meta or with the acid it is capable of being converted int If this white calx be diſſolved in three times its weig

Proceſs for obtaining the arſenical acid.

f boiling muriatic acid in a tubulated retort, and wice its weight of nitrous acid be then added, and e evaporation ſtill continued, the former acid will y off in the elaſtic ſtate; while the nitrous acid will e decompoſed, and will convert the arſenic into a oncrete acid. The purity of this may be aſcertained y igniting it; for this degree of heat will drive off ny portion of the other acids that may remain.

Characters of arſenical acid.

The arſenical acid is much more fixed in the fire han the calx itſelf; it may even be fuſed into a ranſparent glaſs. It is ſlightly deliqueſcent, and re-uires twice its weight of water to diſſolve it. This cid forms a ſaline combination with argillaceous arth, which coagulates as ſoon as it arrives at the oint of ſaturation. With lime it forms a cryſtal-zable ſalt. With ponderous earth it forms a ſalt f difficult ſolubility. With magneſia it produces a oagulum, or gelatinous ſubſtance. It does not act pon ſiliceous earth, unleſs perhaps in the dry way.

Combinations with earths;

—with alkalis.

The combination of this acid with vegetable alkali rms a deliqueſcent ſalt, which does not cryſtallize; ut if there be a ſmall exceſs of the acid, the ſolution ill afford fine cryſtals, which are the neutral arſe-ical ſalt of Macquer. The mineral alkali, ſaturated ith arſenical acid, affords a cryſtallizable ſalt nearly eſembling the foregoing. It unites likewiſe with the olatile alkali, and forms a ſalt in cryſtals. When is is expoſed to diſtillation, part of the alkali is de-ompoſed; phlogiſticated air is given out; and the cid, being reduced to the calciform ſtate, ſublimes.

Page 124.

Mere heat in an open veſſel gradually reduces e acid of arſenic to the ſtate of calx, which ſub-limes.

Reduction of arſenical acid.

limes. When the fluid acid is digeſted with charcoal powder, no change takes place until the moiſture is evaporated; and when the heat is raiſed to ignition, a ſudden combuſtion takes place, all the acid is reduced and ſublimed into the neck of the retort, the greater part being in the form of the metallic regulus, and the reſt calx. Continued digeſtion with oils revives this acid.

Combination with ſulphur.

It unites with ſulphur by fuſion, the whole maſs riſing almoſt inſtantly in the form of a red ſublimate, at the ſame time that volatile ſulphureous acid paſſes into the receiver.

Theory.

The theory of theſe facts will not be difficult to the reader who has attentively conſidered the preceding chapters. The white calx of arſenic was diſſolved in marine acid; becauſe it is required to be had in a ſtate of extreme diviſion, and becauſe the nitrous acid can only diſſolve it very ſparingly. The nitrous acid is added; becauſe it readily gives out vital air (and perhaps abſorbs phlogiſton), while it becomes converted into nitrous air, which flies off. The calx of arſenic thus becomes completely acidified. This acid, at a ſtrong temperature, decompoſes volatile alkali, which is a compound of phlogiſticated and inflammable air. This laſt principle either affords phlogiſton to the acid, and reduces it to the ſtate of a calx; or, according to the new theory, performs the ſame thing by uniting with the vital air, and forming water. And a ſimilar explanation will ſerve for the effects of charcoal, or oils, which either afford phlogiſton, or abſorb the vital air. With reſpect to the effects of ſulphur, part of it is acidified by combuſtion, or combination with the vital air of the acid, and comes over in the form

itriolic acid air; while the reſt combines with the
nic, which is reduced, but in what degree does not
rly appear.

Characters of molybdena.

Iolybdena is a ſubſtance which greatly reſembles
nbago, or black lead; but its texture is ſcaly, and
not eaſily pulveriſed, on account of a degree of
ibility which its laminæ poſſeſs. If it be tritu-
d in a mortar with vitriolated tartar, this ſaline
tance will, by the hardneſs and angular figure of
particles, render it more eaſily pulverable; and
n this purpoſe is accompliſhed, the ſalt may be
hed away by ſeveral affuſions of water. If the
der be then placed in a retort, with five or ſix times
weight of diluted nitrous acid, and diſtillation be
ied on to dryneſs, it is found that volatile vitriolic
and nitrous air are extricated, and the colour of
reſidue becomes lighter. More acid muſt then be
d, and the diſtillation again repeated till the
th or fifth time. A ſtrong heat is required to
e off the laſt portions of vitriolic acid formed by
ſulphur. When no more red vapours appear,
reſidue will be white and pulverulent, reſembling
k. This is the acid of molybdena. It requires
five hundred times its weight of boiling water
iſſolve it, and exhibits weak acid properties.

Proceſs for obtaining the acid of molybdena.

Combinations.

his acid combines with lime, magneſia, and cal-
ous earth, with which it forms ſalts of very diffi-
ſolution. When added to a ſolution of ponderous
h in the nitrous or marine acids, it forms a com-
nd which is ſparingly ſoluble in cold water; and,
that account, falls to the bottom. The combi-

nation of this acid with vegetable alkali is more ſoluble in water than the acid itſelf, and affords cryſtals by evaporation. It unites likewiſe with the volatile alkali. Several of the metals, when diſſolved, are likewiſe ſeized by this acid, and precipitated from their ſolutions.

Regenerated molybdena.

When the acid of molybdena is heated with ſulphur in a retort, placed in ſuch a manner as that the ſublimed ſulphur may melt and run back again, a combination between theſe two ſubſtances is at length produced; and the ſuperfluous ſulphur flies off, being partly converted into volatile vitriolic acid. The reſidue is found to be in every reſpect the ſame as the native molybdena. The analyſis of molybdena by the nitrous acid ſhewed that it conſiſts of ſulphur united to a peculiar acid, or acid baſis; and this ſynthetical production of molybdena proves the ſame thing.

Acid of tungſten, or wolfram.

The acid of tungſten, or wolfram, is a peculiar metallic ſubſtance obtained from theſe minerals. The tungſten is a ponderous ore, of a grey colour, and lamellar texture. It conſiſts of the metallic calx, or acid, united to about its own weight of calcareous earth. Wolfram is a mineral of ſtill greater ſpecific gravity, which is formed in the tin mines of Cornwall, and elſewhere. It is of a browniſh black colour, of a radiated or foliated texture, internally ſhining almoſt with the luſtre of a metal. It is of a moderate hardneſs, though ſometimes ſo friable as to be pulverable between the fingers. It contains about two-thirds of the peculiar calx or acid; and the

Proceſs for obtaining the acid of tungſten, or wolfram.

t conſiſts chiefly of the calces of manganeſe and
n. If either of theſe minerals be pulverized and
eſted in the vitriolic, nitrous, or marine acids (but
latter is the moſt effectual), the calcareous earth
the tungſten, or the manganeſe and iron of the
lfram, which lie on the external ſurfaces of the
ticles, will be diſſolved; and the wolfram calx,
ng laid bare, will exhibit a yellow colour. The
duum, after edulcoration, or waſhing with water,
ng digeſted with volatile alkali, the wolfram calx,
acid, will be taken up, or extracted from the ſur-
e, in the ſame manner; the yellow colour vaniſh-
at the ſame time. This reſidue, after edulcora-
n, will again preſent a ſurface to be acted upon by
marine acid, which will ſeize another ſtratum of
ticles, that in the former digeſtion were defended
the wolfram calx, which was afterwards taken up
the volatile alkali. In this manner, by the alternate
lication of volatile alkali and marine acid, the
neral will at length be almoſt entirely diſſolved.
portions of acid are found to contain either the
es of manganeſe and iron, or elſe calcareous earth,
ording to the mineral made uſe of; and the alka-
ſolvent contains the acid of wolfram. The addi-
of nitrous acid to this laſt fluid precipitates a ſalt
ch has acid properties, and is ſparingly ſoluble in
er. The firſt diſcoverer[*] called it the acid of
gſten, though in fact it contains both volatile al-
i and nitrous acid. It may however be deprived
theſe laſt by calcination, and is then of a brimſtone
ow colour.

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[*] Scheele.

The

The yellow colour produced by applying marine or nitrous acid in a digeſting heat, affords an eaſy method of diſtinguiſhing ſuch minerals as contain wolfram.

Proceſs for obtaining the acid of tungſten, or wolfram.

In the dry way, if the vegetable alkali be fuſed with either of theſe minerals, it takes up the calx or acid. This being diſſolved in water, filtered, and evaporated to dryneſs, muſt be boiled in nitrous acid on a ſand bath. The acid takes up the alkali, and may be decanted off. A repetition of this boiling for two or three times with freſh acid, will effectually carry off the whole of the alkali; and the adhering acid may be driven off by calcination in a cupelling furnace. The powder is then yellow, and does not differ from that obtained by the diſtillation of volatile alkali in the moiſt way.

Characters of the acid.

This matter is not ſoluble in water; but when triturated in that fluid it forms an emulſion, which paſſes through the filtre, and does not completely ſubſide in the courſe of three months. This does not form an emulſion with acids. Pure vegetable alkali diſſolves it, as has been already obſerved; but the produce has always an exceſs of alkali. If more nitrous acid be added than is ſufficient to ſaturate the alkali, a precipitate falls down, which conſiſts of acid, alkali, and wolfram calx. The addition of lime to this, or to the precipitate from volatile alkali, produces a regenerated tungſten, or combination of lime with the wolfram calx or acid; and the alkali, together with the nitrous acid, are found in the ſupernatant fluid.

METALLIC ACIDS.

ſeen * therefore that this yellow matter is either l, or in a ſtate nearly approaching to acidity: not combinable with acids, and unites readily is and calcareous earth.

nic, molybdena, and wolfram, are reducible to tallic ſtate, and will again come under our on when we treat of that claſs of bodies.

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beſt account of this ſubſtance is to be found in "De Chemical Analyſis of Wolfram," of which a tranſla- printed in London, 1785, with Scheele and Bergman's refixed.

BOOK

BOOK II.

RTICULAR CHEMISTRY.

SECTION III.

OF METALLIC BODIES.

CHAP. I.

CONCERNING GOLD.

GOLD.

Characters of gold.

OLD is a yellow metal, of much greater ſpecific gravity than any other body in nature, t platina. It is ſoft, very tough, ductile, and able; unalterable and fixed, whether expoſed to atmoſphere, or to the ſtrongeſt heat of furnaces. moſt powerful burning mirrors are ſaid to have tilized it; and it has been driven up in fumes, in metallic ſtate, by flame urged upon it by a ſtream lephlogiſticated air. The electric ſhock converts to a purple calx, as may be ſeen by tranſmitting that

GOLD.

Obvious properties.

that commotion through gold leaf between two pl
of glaſs; or by cauſing the exploſive ſpark of th
or more ſquare feet of coated glaſs to fall upo
gilded ſurface. A ſtrong heat is required to mel
which does not happen till after ignition. Its col
when melted is of a blueiſh green; and the ſ
colour is exhibited by light tranſmitted through
leaf.

Extreme ductility and tenacity.

The limits of the ductility and malleability of
are not known; and its tenacity exceeds that of
other metal. A gold wire, of one tenth of an
diameter, requires 500lb. weight to break it.

Manufacture of gold leaf:

The method of extending gold, uſed by the g
beaters, conſiſts in hammering a number of thin r
plates between ſkins or animal membranes. By
weight and meaſure of the beſt wrought gold
it is found that one grain is made to cover 56¾ ſq
inches; and from the ſpecific gravity of the m
together with this admeaſurement, it follows,

— its thickneſs.

the leaf itſelf is $\frac{1}{282000}$ part of an inch thick.
however is not the limit of the malleability of g
for the gold-beaters find it neceſſary to add t
grains of copper in the ounce to harden the g
which otherwiſe would paſs round the irregular
of the neweſt ſkins, and not over them; and in u
the old ſkins, which are not ſo perfect and ſmo
they proceed ſo far as to add twelve grains.

Gilt wire.

wire which is uſed by the lace-makers is drawn f
an ingot of ſilver, previouſly gilded. In this
from the known diameter of the wire, or bre
when flattened; and its length, together with
quantity of gold uſed; it is found by comput

ıt the covering of gold is only $\frac{1}{12}$ part of the thick-ſs of gold leaf; though it ſtill is ſo perfect as to hibit no cracks when viewed by a microſcope.

Solvents.

No acid acts readily upon gold but aqua regia and dephlogiſticated marine acid. The vitriolic acid tilled from mangancſe has ſome action upon it; have likewiſe the pale nitrous acid, and the phoſ-oric acid when boiling.

Aqua regia.

The ſmall degree of concentration which the de-logiſticated marine acid is ſuſceptible of, and the perfect action of the latter acids, render aqua regia moſt convenient ſolvent for this metal.

Solution of gold.

When gold is immerſed in aqua regia, an efferveſ-nce takes place with the eſcape of air, which has t been examined; the ſolution tinges animal matters a deep purple, and corrodes them. By careful eva-ration, fine cryſtals of a topaz colour are obtained. ıe gold is precipitated from its ſolvent by a great mber of ſubſtances. Lime and magneſia precipitate n the form of a yellowiſh powder. Alkalis exhibit ſame appearance; but an exceſs of alkali rediſ-ves the precipitate. The precipitate of gold ob-ned from aqua regia by the addition of a fixed ali, appears to be a true calx, and is ſoluble in the riolic, nitrous, and marine acids; from which how-er it ſeparates by ſtanding, or by evaporation of e acids. The nut gall precipitates gold of a reddiſh lour, very ſoluble in the nitrous acid, to which it mmunicates a fine blue colour.

Precipitates:
— by earths and alkalis:

— volatile alkali.

The volatile alkali precipitates the ſolution of gold uch more readily than fixed alkalis. This precipi-te, which is of a brown, yellow, or orange colour, poſſeſſes

GOLD.

Production of fulminating gold.

poſſeſſes the property of detonating with a very conſiderable noiſe when gently heated. It is known by the name of fulminating gold. The preſence of volatile alkali is neceſſary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it by fixed alkali from an aqua regia previouſly made by adding ſal ammoniac to nitrous acid, or by precipitating the gold from pure aqua regia by means of ſal ammoniac inſtead of the volatile alkali alone. The fulminating gold weighs one fourth more than the gold made uſe of. A conſiderable degree of precaution is neceſſary in preparing this ſubſtance. It ought only to be dried in the open air, at a diſtance from a fire, becauſe a very gentle heat may cauſe it to explode. Several fatal accidents have ariſen from its exploſion, in conſequence of the friction of ground ſtoppers in bottl containing this ſubſtance, of which a ſmall portio remained in the neck.

— Analyſis.

Page 50.

Fulminating gold, when expoſed by Berthollet t a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of i fulminating quality, and converted into a calx, at th ſame time that alkaline air was diſengaged. From this dangerous experiment it is aſcertained that fulminating gold conſiſts of calx of gold, combine with the volatile alkali. The ſame eminent philoſoph cauſed fulminating gold to explode in copper veſſel Phlogiſticated air was diſengaged, a few drops of wat appeared, and the gold was reduced to the metall form. From this experiment he infers that the volati alkali was decompoſed; that the phlogiſticated air, ſu

den

aſk, with holes for the eyes defended with ſtrong
ſs.

Fulminating ſilver.

The volatile alkali made uſe of in converting the
of ſilver into the black precipitate, was expoſed
bullition in a ſmall matraſs of glaſs; and the fluid
g then ſuffered to cool, the inſide of the veſſel
ame lined with ſmall cryſtals. When one of theſe
touched beneath the cold liquid, an exploſion took
e, which broke the matraſs in pieces, and threw
liquid up to the ceiling of the laboratory.

Theory of the inventor, page 225:

The inventor's theory of theſe effects is the ſame
that of fulminating gold. The combination con-
of volatile alkali and calx of ſilver; that is to
in the new theory, of inflammable air, phlogiſti-
ed air, ſilver, and vital air. The ſlighteſt change
temperature or agitation diſpoſes the inflammable
to combine with the vital air, which adheres very
ly to the ſilver. Theſe form water, while the
giſticated air is diſengaged, and the ſilver reduced
he metallic ſtate. The exploſion depends on the
len tranſition of the phlogiſticated air and the
er to the elaſtic ſtate by heat: but the change
apacity from which the heat ariſes has not yet
explained. On the phlogiſtic theory, it will be
that the ſilver is revived by combining with the
mmable air, or phlogiſton of the alkali; while the
giſticated and vital air fly off in the exploſion.

— by the phlogiſtic hypotheſis.

Keir's compound acid, page 169.

t is a valuable diſcovery of Mr. Keir*, that a mix-
of ſtrong vitriolic acid with the nitrous acid, or
e, is a powerful ſolvent of ſilver, though it ſcarcely

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* Phil. Tranſ. 1780. p. 367.

SILVER.

acts upon the other metals. This is of conſiderable importance in the Birmingham manufactures, where the ſilver in the cuttings of plated copper is required to be ſeparated from this laſt metal. For this purpoſe the pieces of metal are put into a glazed earthen pan, and a compoſition of eight or ten pounds of oil of vitriol, with one pound of nitre, is poured upon them, ſtirred about, and the action of the fluid aſſiſted by a heat between 100° and 200° of Fahrenheit. When the liquor is nearly ſaturated, the ſilver is to be precipitated by common ſalt, which may be eaſily afterwards reduced; or, otherwiſe, the ſilver may be precipitated in its metallic ſtate by adding to the ſolution a few of the pieces of copper, and a ſufficient quantity of water, which enables the liquor to act on the copper. The theory of this effect ſtill remains to be inveſtigated.

Sulphur combines readily with ſilver in the dry way but may be ſeparated by a ſtronger heat. The ſulphur of liver of ſulphur likewiſe blackens ſilver, an combines with it, whether the ſilver be immerſed i the liquid ſolution, or expoſed to hepatic air.

Action of aqua regia upon ſilver.

Aqua regia acts ſtrongly on ſilver; but precipitat it in the form of luna cornea as faſt as it is diſſolve This effect may be eaſily underſtood by conſiderin that the nitrous acid diſſolves the ſilver, and the m rine precipitates it.

The neutral ſalts alone do not alter ſilver either the moiſt or dry way; nitre, in particular, does n deflagrate with this metal.

Precipitation of ſilver by metals.

Moſt metallic ſubſtances precipitate ſilver in t metallic ſtate from its ſolution. The aſſayers ma

SILVER.

Tree of Diana.

ſe of copper to ſeparate the ſilver from the nitrous
cid uſed in the proceſs of parting. The precipita-
on of ſilver by mercury is very ſlow, and produces
peculiar ſymmetrical arrangement, called the tree of
iana. In this, as in all precipitations, the peculiar
rm may be affected by a variety of concomitant
rcumſtances; for which reaſon one proceſs uſually
cceeds better than another. Lemery directs that
ounce of fine ſilver be diſſolved in a ſufficient
uantity of very pure and moderately ſtrong nitrous
id; that this ſolution be mixed in a matraſs, or
ttle, with about twenty ounces of diſtilled water;
nd that, after the addition of two ounces of mer-
ury, the whole be ſuffered to repoſe. During
e ſpace of forty days a kind of tree of ſilver will
formed on the ſurface of the mercury, with
anches greatly reſembling a vegetable ſubſtance in
s ramifications. The foregoing proceſs is ſaid by
acquer to ſucceed very well; but the following, of
omberg, is much ſhorter.

Proceſs of Lemery.

Homberg's proceſs for making the tree of Diana.

Make an amalgam, without heat, of four drams of
af ſilver, with two drams of mercury. Diſſolve
is amalgam in four ounces, or a ſufficient quantity
pure nitrous acid of a moderate ſtrength; dilute
is ſolution in about a pound and a half of diſtilled
ater; agitate the mixture, and preſerve it for uſe
a glaſs bottle, with a ground ſtopper. When this
eparation is to be uſed, the quantity of one ounce
put into a phial, and the ſize of a pea of an amal-
am of gold or ſilver, as ſoft as butter, is to be added;
ter which the veſſel muſt be left at reſt. Soon
terwards ſmall filaments appear to iſſue out of the

SILVER.

ball of amalgam, which quickly increaſe, and ſhoot out branches in the form of ſhrubs.

Theoretical obſervations.

In the above experiment of Lemery the nitrous acid depoſits its ſilver at the ſame time that it takes up mercury; and, in conſequence of the liquor being ſo much diluted, the proceſs goes on ſlowly, and the precipitated ſilver has time to arrange itſelf according to the law of its cryſtallization, whether that depend on the polarity of its particles, or on any other property not yet explained. In the method of Homberg there are two circumſtances which appear calculated to forward the proceſs: in the firſt place, the nitrous acid already contains mercury in ſolution, which may probably render it more diſpoſed to part with the ſilver; and, in the next place, the mercury is combined with ſilver or gold in the form of an amalgam. Theſe may perhaps facilitate the precipitation of the ſilver, by preſenting a baſe for it to combine with; whicl may be more perfectly at repoſe, becauſe leſs agitabl than the fluid mercury in the former experimen After all, however, though the general theory of th experiment is not difficult, yet it does not ſeem ea to point out the effectual cauſe of the differences between the two reſults.

Page 81.

Combinations of ſilver; with gold:

— with platina:

Silver unites with gold by fuſion, and forms pale alloy, as has been already mentioned in treatin of that metal. With platina it forms a hard mixture, rather yellower than ſilver itſelf, and of difficult fuſion. The two metals do not unite wel Silver melted with one tenth part of crude platin from which the ferruginous particles had been ſep rated by a ſtrong magnet, could not be render

lear of ſcabrous parts, though it was repeatedly fuſed,
oured out, and laminated between rollers. It was
hen fuſed, and ſuffered to cool in the crucible, but
ith no better ſucceſs. After it had been formed, by
olling and hammering, into a ſpoon for blow-pipe
xperiments, it was expoſed to a low red heat, and
ecame rough, and bliſtered over its whole ſurface.
he quantities were one hundred grains of ſilver,
nd ten grains of platina. Nitre was added during
he fuſions.

Combinations of ſilver with mercury:

—with lead:

—with copper:

—with tin, &c.

Silver very readily combines with mercury. A
ery ſenſible degree of heat is produced when ſilver
af and mercury are kneaded together in the palm of
e hand. With lead it forms a ſoft maſs, leſs ſono-
ous than pure ſilver. With copper it becomes
arder and more ſonorous, at the ſame time that it
mains ſufficiently ductile: this mixture is uſed in
e Britiſh coinage. Fifteen parts of ſilver, alloyed
ith one of copper, form the compound called ſtand-
rd ſilver. The mixture of ſilver and iron has been
tle examined. With tin it forms a compound
hich, like that of gold with the ſame metal, has
een ſaid to be brittle, however ſmall the proportion;
ough there is probably as little foundation for the
ſertion in the one caſe as in the other. With
iſmuth, arſenic, zinc, and antimony, it forms brittle
ompounds. It does not unite with nickel. The
ompound of ſilver and wolfram, in the proportion
f two of the former to one of the latter, was ex-
nded under the hammer during a few ſtrokes; but
fterwards ſplit in pieces.

Native ſilver and its ores.

Silver is found either native or mineralized. The native ſilver is found in Peru, and various parts of Europe; ſometimes in conſiderable maſſes, and often diffuſed through ſand, ochre, or lime-ſtone. It is ſeldom pure, but is generally alloyed with copper, and ſometimes with gold, iron, or regulus of antimony. The mineralized ſilver contains ſulphur and arſenic, or both, with other admixtures.

Purifying of native ſilver.

Native ſilver may be purified by pounding or waſhing, or amalgamation with mercury; and the ſilver itſelf is refined by cupellation with lead in the ſame manner as gold. In the large way, the litharge, or vitrified lead, is blown from the ſurface of the ſilver by bellows, inſtead of ſoaking into the crucible. Gold may be ſeparated from ſilver by parting with aqua regia, or treatment with ſulphur in the dry way, which combines with the ſilver, and leaves the gold diſengaged.

Vitreous ore of ſilver.

The vitreous ſilver ore is the richeſt ore of ſilver, and contains from ſeventy to eighty pounds of ſilver in the hundred weight; the reſt being ſulphur, with rarely any other metal, except a ſmall portion of iron. It is found either in ſolid large lumps, or inheren in quartz or ſpar. Its colour generally reſembles tha of lead; but grows dark by expoſure to the air. I uſually poſſeſſes a ſlight degree of malleability, and i ſufficiently ſoft to be cut by a knife.

Analyſis in the moiſt way:

To analyſe this ore in the moiſt way, it may b boiled in nitrous acid, which acidifies the ſulphu and cauſes great part to fly off in the form of vitriol acid air. Common ſalt, or marine acid, will prec

pita

SILVER.

itate the ſilver in the form of luna cornea, which ay be either reduced or accounted for by deducting ne fourth of its weight when waſhed and dried, hich fourth of its weight is marine acid.

— in the dry way.

In the dry way, it may be reduced by expoſing it o a heat not ſufficient to melt it. In this way the lphur is diſſipated, and the ſilver remains uſually a fibrous form. Small portions may be conve-iently decompoſed in this manner by the blow-pipe pon charcoal.

Red ſilver ore.

The red ſilver ore is a heavy ſhining ſubſtance, ither tranſparent or opake; ſometimes grey or lackiſh, but always reddiſh when powdered: it uſu-lly contains more than half, and ſometimes $\frac{3}{4}$ of its eight of ſilver, the reſt being arſenic and ſulphur.

Analyſis in the moiſt way.

In the moiſt way, this ore is analyſed by reducing to fine powder, and boiling it with diluted nitrous cid. The reſidue, which contains the ſulphur and e arſenic, muſt be edulcorated with water; and the ſenic may be diſſolved by boiling in a ſufficient antity of aqua regia If the ſulphur ſhould retain ny luna cornea, it may be ſeparated by keeping it r ſome days in a cloſed veſſel, with its own weight diluted cauſtic volatile alkali. The clear nitrous lution being mixed with the water uſed in the eduſ-ration, affords a precipitate of luna cornea by the dition of ſea ſalt, which may either be reduced or counted for in the ſame manner as in the aſſay of e vitreous ſilver ore.

White ore of ſilver analyſed.

Silver united with ſulphur, arſenic, and copper, is nerally called the white ore of ſilver. One hundred ains of this being reduced to a powder, and gently boiled for an hour in more than twelve times its weight of diluted nitrous acid, the copper and ſilver are diſſolved, and a white reſiduum remains. The ſilver is precipitated in the metallic form by the immerſion of a clean plate of copper; and the copper being afterwards precipitated by the addition of volatile alkali, may be accounted for by allowing 194 grains of the precipitate to one hundred of the copper, and deducting the loſs ſuſtained by the plate of copper which was immerſed in the ſolution. The white reſiduum may be deprived of its arſenic and iron by boiling in marine acid. The arſenic may be precipitated by the addition of water; and afterwards the iron, if any, by Pruſſian alkali. The undiſſolved ſulphur may be treated with volatile alkali, to try whether it contains either copper or luna cornea.

The other ores of ſilver, of which there is conſiderable variety, may be analyſed by varying the proceſſes according to the ſuppoſed or known general contents of the ore *.

Method of aſſaying ſilver, or its ores, in the dry way.

Sulphureous and arſenical ſilver ores may be aſſayed by roaſting and ſubſequent fuſion with a greater or leſs quantity of flux. In the fuſion, the ſilver is obtained alloyed with lead, copper, or iron, which may be ſeparated by cupellation with lead, and the ſilver left pure. The fineneſs of ſilver is denoted by the aſſayers, by mentioning the number of pennyweights and grains of pure ſilver contained in the ounce. S

See page 231.

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* For which conſult Bergman's Treatiſe on the Art of Aſſaying in the Humid Way, inſerted in the 2d vol. of the Engliſh tranſlation of his Opuſcula, or Eſſays.

th

at if an ounce of ſilver be found to loſe half a
nnyweight by cupellation, it is ſaid to be eleven
nnyweights twelve grains fine; if it loſe a whole
nnyweight, it is ſaid to be eleven pennyweights fine,
c. Silver is likewiſe tried by the touch, in the ſame
nner as gold. For this purpoſe, the aſſayers are
ovided with a ſet of needles or ſmall bars; the firſt
which contains $\frac{1}{16}$ part of its weight of copper,
d the reſt ſilver; the ſecond contains $\frac{2}{16}$ parts of
pper; the third $\frac{3}{16}$ parts; and ſo on to the laſt,
hich contains 15 parts of copper to one of ſilver.
y the reſemblance of colour on the touchſtone, an
timate may be made of the fineneſs of the ſilver to
mething nearer than the 30th part of the whole,
hich is a conſiderable acquiſition in the examination
ſmall articles, ſuch as rings, trinkets, and the like.
is true indeed that the uſe of the touch ſuppoſes
e precious metal to be alloyed with copper only,
hich may not be the caſe; and conſequently the
ſayer is liable to be deceived in this reſpect: but
may in this caſe have recourſe to aqua fortis, or
e blow-pipe, in the ſame manner as directed in the
regoing chapter.

Page 233, 234. Aſſay of ſilver by the touch.

In the large works, where ſilver is extracted, the
oceſſes are grounded on the properties already de-
ribed. Native ſilver is triturated with mercury;
ter which the amalgam is waſhed, to ſeparate the
rthy particles; and the quickſilver ſeparated, partly
y preſſure in leathern bags, and partly by diſtillation
1 iron retorts.

Extraction of ſilver from ores in the large way, by amalgamation:

Rich ſulphureous ores are roaſted, and fuſed with
ad, to refine the ſilver by cupellation. The poorer
ores,

—by fire.

ores, which contain copper, are fuſed with pyrites, which affords a maſs conſiſting of copper, ſulphur, and ſilver. Lead is then added, and the maſs treated in the way of eliquation. The lead flows out, carrying the ſilver with it; and, laſtly, theſe two metals are ſeparated by the teſt, on which the lead is converted into litharge, and the ſilver remains pure.

Uſes of ſilver.

The uſes of ſilver are well known: it is chiefly applied to the forming of various utenſils for domeſtic uſe, and as the medium of exchange in money. Its diſpoſition to aſſume a black colour by tarniſhing, and its ſoftneſs, appear to be the chief objection to its uſe in the conſtruction of graduated inſtruments for aſtronomical and other purpoſes, in which a good white metal would be a deſirable acquiſition.

CHAP.

CHAP. III.

CONCERNING PLATINA.

PLATINA.

Characters of platina.

ATINA is one of the metals for the diſcovery of which we are indebted to our cotempora- It has yet been found only in Spaniſh rica, among the gold mines there. We receive the form of ſmall particles, from the minuteſt up to that of a pea; though theſe laſt are very m met with. Its particles or grains are ſmooth, ularly figured with round edges, and are flattened, ably by hammering in the mills in which the is amalgamated. Theſe grains are of a whiter ur than iron, and are conſiderably malleable. In ſtate in which we receive them, they are often mix- ith ferruginous ſand, which may be ſeparated by magnet; and alſo with grains of quartz or cryſtal. n it is ſeparated from heterogeneous particles, crude platina itſelf is ſlightly magnetic, and is een ſixteen and eighteen times as heavy as water. moſt violent fires are inſufficient to melt it, gh its parts may be made to cohere together into lid button by the ſtrong heat of a wind furnace. ning lenſes of the moſt powerful kind fuſe it, and vert it into a malleable metal; and ſmall portions crude platina may be eaſily melted upon charcoal, flame urged by a ſtream of vital air.

Crude platina.

Pure platina.

ure or refined platina is by much the heavieſt ly in nature. It is very malleable, though conſi- derably

PLATINA.

Characters of platina.

derably harder than either gold or ſilver; and it hard much under the hammer. Its colour on the tou ſtone is not diſtinguiſhable from that of ſilver. Wh in the higheſt degree of purity, it is not mag tical; but when its ſpecific gravity is as low 21.36 it contains iron ſufficient to render it mag tical. Pure platina requires a very ſtrong heat melt it; but when urged by a white heat, it is that its parts will adhere together by hammeri This property, which in iron is diſtinguiſhed by

Welding.

name of welding, is peculiar only to platina and t metal, which reſemble each other likewiſe in th infuſibility.

Solution in dephlogiſticated marine acid:

Platina is not altered by expoſure to air; neither it acted upon by the moſt concentrated ſimple ac even when boiling, or diſtilled from it. The depl giſticated or aërated marine acid diſſolves it, as d likewiſe aqua regia; and both are ſaid to form ſame ſalts with it. In this particular of ſolubi platina reſembles gold.

—in aqua regia.

The aqua regia beſt adapted to the ſolution platina is compoſed of equal parts of the nitrous marine acids. The ſolution does not take place w rapidity. A ſmall quantity of nitrous air is diſ gaged; the colour of the fluid becoming firſt yell and afterwards of a deep reddiſh brown, which, u dilution with water, is found to be an intenſe yell This ſolution is very corroſive, and tinges ani matters of a blackiſh brown colour: it affords c

Diſtinctive character.

tals by evaporation. The metal is precipitable f its ſolution by ſal ammoniac; a property by whic is diſtinguiſhed from all other metals, in the ſ

man

ner as the ſolution of gold is characterized by its ipitation upon the addition of martial vitriol. In way, a compound ſolution of gold and platina be ſeparated by precipitating either of the two ls at pleaſure. The orange-coloured precipitate latina, obtained by means of ſal ammoniac, is a e ſubſtance, completely ſoluble in water; but its ponent parts have not been well aſcertained. It ſible without addition by a good forge furnace, forms a brilliant, denſe, and cloſe-grained button, h is not malleable, probably on account of part he ſaline ſubſtance not being diſſipated. The precipitate, expoſed to the ſtronger heat of a furnace, was fuſed into a perfectly malleable lus *.

Separation of gold from platina.

Malleable platina.

Precipitates.

lkalis and the ſoluble earths precipitate platina in form of a calx from its ſolution. The Pruſſian i hereafter to be deſcribed does not precipitate it does all other metals; but it throws down ntiful blue precipitate, conſiſting of iron, which contained in the Pruſſian blue. This property efore affords a method of ſeparating the iron platina, which always contains it. The vola-

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By the Count de Milly. See Magellan's Cronſtedt, page —I have ſeveral ſmall ſpecimens of this platina, which is in plates or bars; their ſpecific gravity is above $21\frac{1}{2}$; in h I do not pretend to a greater accuracy than $\frac{1}{200}$th part of weight, becauſe the quantities are ſo ſmall. It is perfectly eable, hard, and elaſtic, and obeys a ſtrong magnet when pieces are floated upon water: one ſmall piece which was l by Parker's lens is not at all magnetical, and ſeems to ex- 22 in ſpecific gravity.

tile

tile alkali precipitates platina of an orange yellow lour. Neutral ſalts, with baſe of fixed alkali, do precipitate it.

Precipitates.

Moſt of the metals precipitate platina from its lution; but it does not in general fall down in metallic ſtate.

This metal is not affected in the dry way by line ſubſtances. Calx of arſenic facilitates its fuſ and the ſemi-metal forms a brittle compound w the platina. Mr. Achard ſucceeded in making cr bles of platina, by fuſing equal parts of platina, w arſenic, and vegetable alkali. This matter, w cooled, was reduced to a powder, and rammed the mould of the veſſel intended to be formed. ſtrong heat, quickly raiſed, and continued for ſ time, fuſed the maſs; and, after diſſipating the arſ and the alkali, left the platina in the form deſired.

Crucibles of platina.

Combinations of metals.

Platina does not readily combine with gold, ex by a ſtrong heat; and it greatly debaſes the colou that metal: it does not readily unite with ſilver which however it communicates part of its h neſs, while it impairs its colour and brilliancy altogether reſiſts the action of mercury; or at this mutual action does not ſeem to be ſtronger that of mercury and iron. Lead and platina very well by fuſion; the lead becomes much ductile, and even brittle, according to the propor of the platina. In the attempts to cupel platina lead, the proceſs went on as it does uſually with and gold in the beginning; but as ſoon as a co rable portion of the lead was diſſipated, the p fixed, and the operation ceaſed. But with a ſtr

Cupellation.

PLATINA.

Combinations with metals.

t, ſuch as that of a porcelain furnace, the opera-
may be completed, and malleable platina obtained
from lead. It has not been united with forged
; but with caſt iron it formed a brittle compound.
h copper it melts with conſiderable facility; and
ue proportions forms a compound which takes a
beautiful poliſh, and is not ſubject to tarniſh:
has been uſed for the mirrors of reflecting tele-
es. Tin and platina melt very eaſily, and form a
pound, ſcarcely ductile when the tin abounds,
very brittle when the platina predominates. Biſ-
h and antimony unite with platina by fuſion, and
n brittle compounds, which do not promiſe to be
ny conſiderable utility. Zinc likewiſe combines
lily with it, and renders it very fuſible; this alloy
rittle, hard, and of a blueiſh colour. Wolfram can
cely be brought to ſhew any ſign of union with
ina. Cobalt, manganeſe, and molybdena have not
tried.

CHAP. IV.

CONCERNING MERCURY.

MERCURY.

Characters of mercury.

MERCURY is diſtinguiſhed from all other metal by its extreme fuſibility, which is ſuch th it does not take the ſolid ſtate until cooled to th thirty-ninth degree below 0° on Fahrenheit's thermo meter; and of courſe it is always fluid in the tem perate climates of the earth. Its colour is white, an rather bluer than ſilver. In the ſolid ſtate it is mal leable *; its ſpecific gravity is greater than that o any of the other metals, platina, gold, and wolfra excepted. It is volatile, and riſes in ſmall portion at the common temperature of the atmoſphere, as evinced by ſeveral experiments, more eſpecially in vacuum, ſuch as obtains in the upper part of a bar meter tube. At the temperature of about ſix hu dred degrees it boils rapidly, and riſes copiouſly fumes. Few of the other metals melt at ſo low temperature as the boiling point of mercury. Wh expoſed to ſuch a heat as may cauſe it to riſe quick in the vaporous form, it gradually becomes convert into a red calx, provided vital air be preſent. This known by the name of precipitate per ſe. A great heat however revives this metallic calx, at the ſam time that the vital air is again extricated.

Precipitate per ſe.

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* The reader will find an ample account of the freezing quickſilver in Dr. Blagden's Hiſtory, Vol. LXXIII. of Philoſophical Tranſactions.

MERCURY.

Characters.

Mercury is not perceptibly altered by expoſure to air; though by long agitation, with acceſs of air, becomes converted into a black powder or calx, ich gives out vital air by heat, the metal being at ſame time revived. This metal is diſpoſed to at-ct moiſture; and cannot, for that reaſon, be uſed the conſtruction of barometers and thermometers il it has been firſt boiled in an open veſſel for the ce of about half an hour.

Electric light.

When mercury is agitated in a dry glaſs bottle, the tion between the metal and the glaſs produces tricity. If the bottle be imperfectly exhauſted, electricity paſſes into the vacuum, and produces ight which was formerly thought to be a proof of perfection of the vacuum in the upper part of ometer tubes; but which in fact does not appear uch barometers as have been cleared of air by care- boiling in the tube.

Action of vitriolic acid on mercury.

he vitriolic acid does not act on this metal, unleſs e well concentrated and boiling. For this purpoſe, cury is poured into a glaſs retort, with near twice weight of vitriolic acid. As ſoon as the mixture eated, a ſtrong effervefcence takes place, vitrio- cid air eſcapes, the ſurface of the mercury becomes te, and a white powder is produced; when the olic air ceaſes to come over, the mercury is found be converted into a white, opake, cauſtic, ſaline s, at the bottom of the retort, which weighs one d more than the mercury, and is decompoſed by t. Its fixity is conſiderably greater than that of cury itſelf. If the heat be raiſed, it gives out a confiderable quantity of vital air, the mercury being at the ſame time revived.

Vitriol and calx of mercury.

Turbith mineral.

The white maſs produced by the action of vitriolic acid upon mercury, conſiſts partly of a ſaline maſ, or vitriol of mercury, and partly of a calx, or mercury united to vital air (ſimply, according to the nev theory; or deprived of phlogiſton, according to the ol theory, which phlogiſton is ſuppoſed to enter into th combination of the vitriolic acid air). Water ſeparates the ſalt from the calx, which laſt is then of yellow colour. Much waſhing is required to produc this colour, if cold water be uſed; but if a large quantity of hot water be poured on, the calx immediate aſſumes a bright lemon colour. In this ſtate, it called turbith mineral.

Precipitates.

The vitriol of mercury affords a ſalt by evaporatio in ſmall needle-formed deliqueſcent cryſtals. The a dition of a large quantity of water, more eſpecially heated, decompoſes vitriol of mercury, which depo turbith mineral, unleſs there be an exceſs of acid the fluid.

The fixed alkalis, magneſia, and lime, precipi mercury from its ſolution: theſe precipitates are re cible in cloſed veſſels by mere heat without addition.

Solution in nitrous acid.

Page 164.

The nitrous acid rapidly attacks and diſſolves m cury, at the ſame time that a large quantity of nitr air is diſengaged; and the colour of the acid beco green during its eſcape. Strong nitrous acid takes its own weight of mercury in the cold; and this ſo tion will bear to be diluted with water. But if ſolution be made with the aſſiſtance of heat, a m larger quantity is diſſolved; and a precipitate of

ill be afforded by the addition of diſtilled water,
hich is of a yellow colour if the water be hot, or
iite if it be cold, and greatly reſembles the turbith
neral produced with vitriolic acid: it has accord-
gly been called nitrous turbith. If acid be added
the ſolution made with heat, it loſes its property of
ing decompoſed by water. This decompoſition is
c complete, but only deprives the acid of the re-
ndant calx.

Nitrous turbith.

Mercurial nitre.

All the combinations of mercury and nitrous acid
: very cauſtic, and form a deep purple or black
ɔt upon the ſkin. They afford cryſtals, which differ
cording to the ſtate of the ſolution. When nitrous
d has taken up as much mercury as it can diſ-
ve by heat, it uſually aſſumes the form of a white
ine maſs. When the combination of nitrous acid
d mercury is expoſed to a gradual and long continued
v heat, it gives out a portion of nitrous acid, and
comes converted into a red ſubſtance, ſimilar in all
pects to the red calx of mercury formed by ſimply
iting it in contact with vital air. This is known
the name of red precipitate.

Red precipitate:

—decompoſed.

When red precipitate is ſtrongly heated, a large
antity of vital air is diſengaged, together with ſome
ogiſticated air, and the mercury is ſublimed in the
tallic form.

Mercurial nitre is more ſoluble in hot than cold
ter, and affords cryſtals by cooling. It is decom-
ſed by the affuſion of a large quantity of water,
leſs the acid be in exceſs.

When mercury is diſſolved in nitrous acid by means
heat, nitrous air is emitted at firſt; and after-

wards

Nitrous ſolution.

wards it ceaſes, though the ſolution ſtill proceeds
The mercury which is taken up during the firſt par
of the proceſs is calcined, and the other portion i
diſſolved in the metallic ſtate. If the ſolution b
ſtopped in the firſt part of the proceſs, fixed and vol
tile pure alkalis precipitate the yellow calx; but if th
ſolution be continued after the eſcape of the elaſt
fluid has ceaſed, the precipitate obtained by the ſan
means is black, on account of the admixture of m
tallic mercury, which may be ſeparated from the ye
low calx by diſtillation.

Precipitates.

Ponderous earth, magneſia, and lime, precipita
the nitrous ſolutions of mercury; and theſe preci
tates, as well as all the other calces of this metal, a
reducible by heat alone without addition.

Exploſion of mercurial precipitates.

The precipitates of mercury from acids, by mea
of alkalis, poſſeſs the property of exploding when
poſed to a gradual heat in an iron ſpoon, after havi
been previouſly triturated with $\frac{1}{6}$ of their weight
flowers of ſulphur. The reſidue conſiſts of a viol
coloured powder, which is converted by ſublima
into cinnabar. It ſeems therefore as if the ſulp
combined ſuddenly with the mercury, and expe
vital air in the elaſtic ſtate.

Decompoſition of the nitrous ſolution by other acids.

The vitriolic acid, or the ſalts containing it,
compoſe the nitrous ſolutions of mercury by vi
of the ſtronger attraction of the vitriolic acid
the metal. The precipitate which falls down
not eſſentially differ from the ſubſtance prod
by the direct ſolution of mercury in the vitr
acid. The marine acid likewiſe ſeizes the mer
diſſolved in the nitrous acid, and forms a comp

Page 257.

Corroſive ſublimate.

h falls to the bottom. This conſiſts of a very uſtic ſalt, which is called corroſive ſublimate, and produced when the nitrous ſolution contains only x of mercury; but when that ſolution is ſaturated th metallic mercury, the compound which falls wn by the addition of marine acid is called white ecipitate, and does not differ from the preparation ich, when made in the dry way, is called calomel, mercurius dulcis.

Page 263. Calomel.

The acetous and moſt other acids combine with calx of mercury, and precipitate it from its ſolun in the nitrous acid.

Combination of mercury with dephlogiſticated marine acid.

The marine acid does not act perceptibly upon rcury in the metallic ſtate; but the dephlogiſtied or aërated marine acid readily diſſolves it, and ms the ſame combination as ariſes from the direct on of marine acid with calx of mercury; that is ay, corroſive ſublimate.

Preparation of corroſive ſublimate.

The great ſpecific gravity of mercury rendered it an ect of peculiar attention to the alchemiſts and earlier miſts; many of whom hoped to fix it in the form of lid ſubſtance, or to extract gold from it. From ſe motives, a great variety of proceſſes have been le with it, by methods which are much leſs direct ſimple than thoſe of modern chemiſtry. Among ers, the combination of the calx of mercury with ine acid is produced by ſeveral methods in the dry by ſublimation. In the large way, corroſive ſubate is prepared by triturating equal parts of mery, common ſalt, and vitriol together, and expoſing whole to a moderate heat. The corroſive ſublie riſes, and adheres to the upper part of the glaſs veſſel.

Corroſive ſublimate.

veſſel. In this operation, the vitriolic acid from the vitriol is ſuppoſed to calcine the mercury, or to dephlogiſticate the marine acid of the common ſalt; in either of which caſes the compound of marine acid with calx of mercury will be formed. From this theory, it will eaſily be underſtood that corroſive ſublimate may be prepared by various methods. If the white maſs or calx of mercury, produced by expoſing that metal to the action of vitriolic acid, be heated in a matraſs with an equal quantity of common ſalt, this ſublimate will be had by double affinity; the vitriolic acid partly ſaturating the alkali, and the marine acid uniting with the calx of mercury, and riſing by ſublimation. In the ſame manner, the nitrous mercurial ſalt, or the mercurial precipitates, may b uſed inſtead of the calx of mercury by vitriolic acid.

Page 257.

Cauſticity of metallic ſalts.

As the cauſticity of metallic ſalts depends chiefl on the diſpoſition of the calcined metal to reſume th metallic ſtate, at the ſame time that it burns or calcines the ſubſtance to which it may be applied; it i accordingly found that corroſive ſublimate poſſeſ this property in the moſt eminent degree; it is therefore one of the moſt active mineral poiſons. Th ſalt is ſoluble in water, though ſparingly, and alſo i ardent ſpirit. It is precipitated of an orange colo by fixed alkalis. The abſorbent earths likewiſe thro down its calx, Volatile alkali affords a white prec pitate, which ſoon afterwards aſſumes a ſlate colour.

Sal alembroth.

Corroſive ſublimate becomes much more ſoluble water by the addition of ſal ammoniac, with whi it forms a triple compound, called ſal alembroth the alchemiſts, which cryſtallizes by cooling. T dition of a fixed alkali throws down a white calx mercury, called white precipitate in the diſpenſa-ies.

White precipitate.

Preparation of calomel, or mercurius dulcis.

The preparation of calomel is uſually made by tri-:ating corroſive ſublimate in a glaſs mortar with id mercury, added by a little at a time, until no ɔre can be made to diſappear. A ſmall quantity of .ter added to the corroſive ſublimate during this rt of the proceſs, prevents that ſalt from riſing in : form of noxious duſt. In this ſtate, the combi-tion is the ſame as that obtained from the ſaturated :rous ſolution of mercury by the addition of marine id. The mixture of corroſive ſublimate and mer-ry is more perfectly combined by expoſing it to blimation. It adheres to the internal part of the bliming veſſel in the form of a white maſs, of a iated texture. If there be any ſuſpicion of its con-ning corroſive ſublimate, which is not probable account of the more volatile nature of the latter, ey may be ſeparated by means of warm water, the .omel being inſoluble.

Page 261.

Butter of antimony.

When one part of antimony, which is the native mbination or ore of antimony with ſulphur, is tritu-:ed or accurately mixed with two parts of corroſive blimate, and expoſed to diſtillation, the dephlogiſti-ted or aërated marine acid combines with the regu-s of antimony, and riſes in the form of the compound lled butter of antimony; while the ſulphur combines ith the mercury, and forms cinnabar. If the regu-s of antimony be uſed inſtead of the mineral, the ſidue which riſes laſt conſiſts of running mercury, ſtead of cinnabar.

MERCURY.

Mercurial ethiops.

Mercury combines very readily with ſulphur. By trituration in a mortar the mercury diſappears, and forms a black compound with the ſulphur, which is called ethiops mineral, or mercurial ethiops. The combination is more ſpeedily made by mixing fluid mercury with melted ſulphur. In this way three parts of flowers of ſulphur unite with one of mercury. If the ſulphur be ſet on fire, the greateſt part burns, and the remainder is of a violet colour when pulverized. This conſiſts of a more intimate combination of mercury and ſulphur. It riſes in a heat nearly approaching to redneſs; and the ſublimate, which is called cinnabar, contains about $\frac{1}{5}$ part ſulphur, and the reſt mercury. The pigment called vermilion conſiſts of artificial cinnabar reduced to a powder.

Cinnabar or vermilion formed in the dry way:

Livers of ſulphur are decompoſed in the humid way by mercury, which unites with the ſulphur. With the fixed alkaline livers of ſulphur it forms a black powder, or ethiops, by agitation, which in the courſe of a number of years becomes red; but the volatile alkaline hepar, or fuming liquor of Boyle, converts mercury into a fine cinnabar in a very ſhort time. Turbith mineral, and the precipitates of mercury, are likewiſe converted into cinnabar by this alkaline hepar.

— in the humid way.

Unguents, &c.

Mercury unites by trituration with oils and mucilages, with which it forms black or deep blue compounds. A ſmall part of the mercury in theſe ſeems to be in combination, and the reſt in a ſtate of extreme diviſion.

This metal can ſcarcely be exhibited in the dry way on account of its volatility. The degree of heat re-

quire

MERCURY.

Page 256.

ed to convert it into the red calx called preci-te per ſe, is rather lower than its boiling point, a greater reduces it again to the metallic ſtate. calcination and reduction of mercury, without ion, afford one of the ſtrongeſt arguments in ur of the ſyſtem which rejects phlogiſton.

Red calx of mercury, or precipitate per ſe.

the production of the red calx of mercury, it is ired that air be preſent, and the metal kept in a of briſk evaporation. On this account it is found venient that the veſſel ſhould be ſo deep, and its ture ſo ſmall, that the fumes may not make their pe. It may be inferred that in this, as well as r calcinations, there is an abſorption of vital air; e eſpecially as vital air is expelled from the calx by *. When the experiment is made in cloſed veſſels neans of a body of the kind marked C, fig. 15, ſe neck is introduced beneath a jar containing mon air over mercury, the vital part is abſorbed, phlogiſticated or foul air remains; and afterwards, n augmentation of heat, the mercury is revived, e ſame time that it reſtores the conſtitution of the by the emiſſion of the vital air. Ten days or a night's conſtant heat is required to convert a few ns of mercury into precipitate per ſe in the ſmall

Page 93.

Amalgams.

ercury being habitually fluid, very readily com-s with moſt of the metals, to which it commu-ites more or leſs of its fuſibility. When theſe allic mixtures contain a ſufficient quantity of mer-

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* Lavoiſier, Traité Elémentaire de Chimie, page 35.

cury

cury to render them ſoft at a mean temperature, they are called amalgams.

Combinations of metals.

It very readily combines with gold, ſilver, lead, tin, biſmuth, and zinc; more difficultly with copper, arſenic, and regulus of antimony; and ſcarcely at all with platina or iron: it does not unite with nickel or cobalt; and its action on mangancſe, wolfram, an molybdena, is not known. Looking-glaſſes are co vered on the back ſurface with an amalgam of tin In this operation, mercury is poured on tin foil, upo a flat ſtone, and ſpread with a feather till its union wi the tin has brightened every part of its ſurface. A large quantity of mercury is then poured on, and th glaſs is ſlided along the fluid ſurface; upon which i is afterwards preſſed by weights, to exclude the ſupe fluous mercury.

Native mercury and its ores.

Mercury is found native in ſlaty or quartzoſe earth or viſibly diffuſed through maſſes of clay or ſton Native precipitate per ſe, or calx of mercury, h alſo been found; and this metal has likewiſe bee met with in combination with the vitriolic and mari acids. Its volatility may probably have cauſed it to b overlooked in many minerals that may contain it. Th greateſt quantity of mercury is found in combinati with ſulphur, in the form of cinnabar. Mercury is ſcarce metal. Moſt of the mercury in commerce afforded by the mines of Idria in the Auſtrian dom nions, Almaden in Spain, and Guancavelica in Per The native mercury requires little more than wa ing to ſeparate it from its matrix. Cinnabar in t native ſtate is frequently mixed with calcareous eart

Decompoſition of cinnabar.

Purity of mercury.

which caſe the mercury may be ſeparated by diſtilla- ı, becauſe the calcareous earth combines with and ıins the ſulphur. Pure cinnabar may be decom- ed by the addition of about one third of its weight iron. In all caſes wherein pure mercury is re- red, it muſt be diſtilled from cinnabar, or its ſul- ıreous combination. For this purpoſe, the mercury y be converted into ethiops, and diſtilled with twice weight of quicklime or iron filings. Mercury in nmerce is judged to be pure when it is perfectly id, and runs in neat globules, without any pellicle its ſurface, or without ſoiling a funnel of clean ite paper, through which it may be poured by a y ſmall aperture at bottom. If it leaves nothing ıind after evaporation, its purity may be ſtill more ɔended upon.

Humid analyſis of cinnabar.

To analyſe native cinnabar, its ſtony matrix ſhould t be diſſolved in nitrous acid; and the cinnabar, ng diſengaged, ſhould be boiled in eight or ten ıes its weight of aqua regia, compoſed of three rts nitrous, and one marine acid: the mercury may ːn be precipitated in the metallic form by the addi- n of zinc.

Uſes of mercury.

The uſes of mercury have already been mentioned the preſent chapter, and elſewhere. The amalga- ıtion of the noble metals, water-gilding, the making vermilion, the ſilvering of looking-glaſſes, and the eparation of ſeveral powerful medicines, are the incipal uſes to which this metal is applied.

CHAP. V.

CONCERNING LEAD.

LEAD. Characters of lead.

Granulated. Page 65.

LEAD is a white metal, of a conſiderably blu tinge, very ſoft and flexible, not very tenaciou and conſequently incapable of being drawn into fi wire, though it is eaſily extended into thin plates unde the hammer. Its weight is very conſiderable, bein rather greater than that of ſilver. Long before ignition, namely at about the 540th degree of Fahrenheit's thermometer, it melts; and then begins to b calcined, if reſpirable air be preſent. In a ſtrong he it boils, and emits fumes; during which time, if e poſed to the air, its calcination proceeds with con derable rapidity. If melted lead be poured into a bo previouſly rubbed with chalk to prevent its action o the wood, and be continually agitated, it will co crete into ſeparate grains, of conſiderable uſe in va ous mechanical operations, particularly that of weig ing. Lead is brittle at the time of congelation. this ſtate it may be broken to pieces with a hamme and the cryſtallization of its internal parts will exhib an arrangement in parallel lines.

Calcination.

Minium, or red lead.

This metal, during the progreſs of heat, firſt b comes converted into a duſky powder, which by continuation of the heat becomes white, yellow, a afterwards of a bright red inclining to orange colo called minium, or red lead. The proceſs requi conſiderable management with regard to the heat a acc

ſs of air, in the making of red lead. Many days are
ired for this purpoſe. If the heat be too great or
l, the lead becomes converted into a flaky ſub-
ce, called litharge; and a ſtill greater heat con-
s it into a clear, tranſparent, yellow glaſs, which
erfully diſſolves and corrodes metallic calces or
hs; and on this account it uſually finds its way
ugh the crucibles in a ſhort time. It acts more
cultly on argillaceous than on ſilicous earths;
nce it is found that veſſels made of clay mixed
broken pottery are preferable to thoſe that are
poſed of clay and ſand. The calx of lead is a
cipal ingredient in moſt of the modern fine white
ſes. It is more particularly calculated to form the
ſe glaſs uſed to correct the aberration ariſing from
ur in thoſe teleſcopes which are known by the
e of achromatic; becauſe it communicates the
erty of ſeparating the coloured rays from each
r in greater angles than obtain in alkaline glaſſes
qual angles of mean refraction. The imperfection
ch moſt conſiderably affects this kind of glaſs is,
its denſity is ſeldom uniform throughout. The
gularities ſhew themſelves in the form of veins,
ch greatly diſturb the regular refraction.

Litharge and glaſs of lead.

Achromatic teleſcope.

ead is not much altered by expoſure to air or
er; though the brightneſs of its ſurface, when cut
craped, very ſoon goes off. It is probable that a
ſtratum of calx is formed on the ſurface, which
ends the reſt of the metal from corroſion.

Action of air and water on lead;

Moſt of the acids attack lead. The vitriolic acid
s not act upon it, unleſs it be concentrated and
ing. Vitriolic acid air eſcapes during this pro-
ceſs,

— of vitriolic acid.

ceſs, and the acid is decompoſed. When the diſti lation is carried on to dryneſs, a ſaline white ma remains, a ſmall portion of which is ſoluble in wate and is the vitriol of lead: it affords cryſtals. Tl reſidue of the white maſs is a calx of lead.

Combination of nitrous acid and lead.

Nitrous acid acts ſtrongly on lead, and converts into a white calx if the acid be concentrated; but it be more diluted, the calx is diſſolved, and form nitre of lead which is cryſtallizable, and does afford a precipitate by cooling. It detonates on nited coals. Lime and alkalis decompoſe the nitr ſolution of lead. The vitriolic acid added to t ſolution combines with the metallic calx, and f down. The marine acid in the ſame manner car down the lead, and forms a combination called plu bum corneum, which is more ſoluble in water t the horn ſilver.

Plumbum corneum:

— marine acid:

Marine acid acts directly on lead by heat, wh it calcines, and diſſolves part of its calx. The ma ſalt of lead is cryſtallizable.

—acetous acid.

The acetous acid diſſolves lead and its calc though probably the acceſs of air may be neceſ for the ſolution of the metal itſelf in this a

White lead, or ceruſe.

White lead, or ceruſe, is made by rolling lea plates ſpirally up, ſo as to leave the ſpace of a an inch between each coil, and placing them ve cally in earthen pots, at the bottom of which is ſ good vinegar. The pots are to be covered, and poſed for a length of time to a gentle heat in a bath, or by bedding them in dung. The vapou the vinegar, aſſiſted by the tendency of the lea combine with the pure part of the air which is

corrodes the lead, and converts the external
on into a white calx, which comes off in flakes
the lead is uncoiled. The plates are thus
ed repeatedly until they are corroded through.
ſe is the only white ſubſtance uſed in oil paint-
It may be diſſolved without difficulty in the
ous acid, and affords a cryſtallizable ſalt, called

Sugar of lead.

of lead from its ſweet taſte. This, like all the
arations of lead, is a moſt deadly poiſon.

Action of liver of ſulphur on lead:

ver of ſulphur precipitates lead from its ſolu-
, the ſulphur falling down in combination with
lead.

— of alkalis:

Pure alkaline ſolutions diſſolve a ſmall
ion of lead, and corrode a conſiderable quan-
the ſolution is ſaid to give a black colour to
air.

— oils.

ils diſſolve the calces of lead, and become
and conſiſtent; in which ſtate they are uſed
e baſis of plaſters, cements for water works,
, &c.

Habitudes in the dry way.

the dry way, lead alone is calcined and vitrefied.
n fuſed with fixed alkaline ſalts, it is converted
a dark-coloured ſcoria, partly ſoluble in water.
neutral ſalts in general are not acted upon by
Nitre calcines this metal when heated with it,
gh ſcarcely any commotion or apparent flame is
uced by its action. Sulphur readily diſſolves it in
ry way, and produces a brittle compound, of a
grey colour and brilliant appearance, which is
h leſs fuſible than lead itſelf; a property which is
mon to all the combinations of ſulphur with the
fuſible metals.

LEAD.

Habitudes with phoſphoric acid.

The phoſphoric acid, expoſed to heat together wit charcoal and lead, becomes converted into phoſphorus which combines with the metal. This combinatio does not greatly differ from ordinary lead: it is malleable, and eaſily cut with a knife; but it loſes it brilliancy more ſpeedily than pure lead; and, whe fuſed upon charcoal with the blow-pipe, the phoſphorus burns, and leaves the lead behind.

Decompoſition of ſal ammoniac:

Lead decompoſes ſal ammoniac by the aſſiſtance heat: its calces unite with the marine acid of th ſalt in the cold, and diſengage its volatile alka When volatile alkali is obtained by diſtilling ſal a moniac with the calces of lead, the reſidue conſiſts plumbum corneum.

— of common ſalt.

Page 118.

Litharge fuſed with common ſalt decompoſes i the lead unites with the marine acid, and forms yellow compound, at preſent uſed in this country a pigment, for which an excluſive privilege has be granted. The alkali either floats at top, or is vo tilized by the heat if ſtrongly urged. The ſame d compoſition takes place in the humid way, if comm ſalt be macerated with litharge; and the ſolution w contain cauſtic alkali.

Combinations of lead with metals.

Lead unites with moſt of the metals. Gold a ſilver are diſſolved by it in a ſlight red heat. B theſe metals are ſaid to be rendered brittle by a ſm admixture of lead, though lead itſelf is rende more ductile by a ſmall quantity of them. Plat forms a brittle compound with lead; mercury am gamates with it; but the lead is ſeparated from mercury by agitation, in the form of an impalp

bl

LEAD.

powder, vital air being at the ſame time ab-
d. The preſence of vital air is indiſpenſably
ſſary in this proceſs. Copper and lead do not
but with a ſtrong heat. If lead be heated ſo
boil and ſmoke, it ſoon diſſolves pieces of cop-
thrown into it; the mixture when cold is brittle.
union of theſe two metals is remarkably ſlight;
ıpon expoſing the maſs to a heat no greater than
in which lead melts, the lead almoſt entirely
off by itſelf. This proceſs, which is peculiar
ad with copper, is called eliquation. The coarſer
of lead, which owe their brittleneſs and gra-
ted texture to an admixture of copper, throw
p to the ſurface on being melted by a ſmall
. Iron does not unite with lead, as long as
ſubſtances retain their metallic form. Tin
es very eaſily with this metal, and forms a com-
ıd which is much more fuſible than lead by it-
and is for that reaſon uſed as a ſolder for

Combinations of lead and copper; decompoſed by eliquation, or by low heat.

Two parts of lead and one of tin form an
more fuſible than either metal alone: this is
older of the plumbers. Biſmuth combines rea-
with lead, and affords a metal of a fine cloſe
, but very brittle. A mixture of eight parts
uth, five lead, and three tin, will melt in a heat
h is not ſufficient to cauſe water to boil. Regulus
ntimony forms a brittle alloy with lead. Wol-
unites with it into a ſpongy ductile compound,
h ſplits into leaves when hammered. Nickel,
lt, manganeſe, and zinc, do not unite with lead
ıſion.

Plumbers ſolder.

Fuſible mixture.

Revival of the calces of lead.

All the calces of lead are very eaſily revived. Minium, when expoſed to a ſtrong heat, gives out par of the vital air it abſorbed during its calcination but; like the other calces of this metal, it requires th addition of ſome combuſtible ſubſtance for its complete revival. A familiar inſtance of this revival ſeen by expoſing the common wafers to the flame a candle. Theſe wafers are coloured with miniu which is revived by the heat and inflammable ſu ſtance of the wafer, ſo that it falls down in metal globules.

Native lead and its ores.

Analyſis of calciform ores.

Lead is found native, though ſeldom; and alſo the form of a calx, called native ceruſe, or lead ochr or lead ſpar of various colours, red, brown, yello green, blueiſh, and black. Theſe ores, when freed much as poſſible from earthy matter, may be diſſol in diluted nitrous acid. Calx of iron is uſually thro down from the ſolution by boiling. If the lead then precipitated by the mild mineral alkali, a weighed, 132 grains of the dry precipitate will c reſpond with 100 grains of lead in the metallic ſt If the precipitate be ſuſpected to contain copper, may be ſeparated by digeſting in volatile alkali. it be ſuppoſed to contain ſilver and copper, the pr pitate may again be diſſolved in nitrous acid, and ſe rated by the addition of marine acid; which c bining with the metal, produces luna cornea, plumbum corneum; the latter of which, being ſ ble in 30 times its weight of boiling water, be waſhed off, while the ſilver remains undiſſolv or the ſilver, if alone in the precipitate, may taken up by volatile alkali, which will leave the calx of lead of the ſame value with regard to weight as the foregoing. Lead is alſo found mineralized by the vitriolic and the phoſphoric acids: this laſt is of a greeniſh colour, ariſing from a mixture of iron. The vitriol of lead is ſoluble in about 18 times its weight of water. One hundred and forty-three grains of the dried ſalt repreſent 100 grains of lead. The phoſphoric lead ore may be diſſolved in nitrous acid by means of heat, except a few particles of iron, which remain at the bottom. By the addition of vitriolic acid the lead is thrown down in the form of white flakes of vitriol; which, when waſhed and dried, diſcover the quantity of lead they contain, by the ſame allowance of 143 grains of the ſalt to 100 grains of metallic lead. The remaining ſolution being evaporated to dryneſs, affords phoſphoric acid.

Native ſalts of lead.

Humid analyſis of phoſphoric lead ore.

Lead is abundantly found in combination with ſulphur, in the form of heavy, ſhining, black, or blueiſh lead-coloured cubical maſſes, whoſe corners are uſually truncated; its texture is laminated, and its hardneſs variable. This is called galena, or potters lead ore. Moſt lead ores contain more or leſs of ſilver. When antimony enters into its compoſition, the texture is radiated or filamentous. There are alſo lead pyrites, which contain a conſiderable proportion of iron and ſulphur; and red lead ſpar, which conſiſts of lead mineralized by ſulphur and arſenic: this is very ſcarce.

Sulphureous ore of lead; or galena.

If ſulphurated lead be boiled in nitrous or marine acid of a moderate ſtrength, the ſulphur may be obtained

Analyſis of ſulphurated lead.

obtained pure, and collected on a filter. When iron or ſtony particles are contained among the undiſſolved part, the ſulphur may be ſeparated by digeſtion in a ſolution of cauſtic fixed alkali, which converts it into liver of ſulphur, and leaves the other inſoluble matters behind. If the firſt ſolution be made with nitrous acid, it may contain ſilver and lead, which, after precipitation by mild mineral alkali, may be ſeparated by the volatile alkali, as mentioned in the humid analyſis of the calciform ores: when the marine acid is uſed for the ſolution of the ore, a large quantity of plumbum corneum ſeparates, for want of a ſufficient quantity of water to diſſolve it. This requiſite quantity of water muſt be added to diſſolve the ſalt before the precipitate is made by the fixed alkali.

Revival of lead by the blow-pipe.

All the ores of lead, except the phoſphoric, are reducible to the metallic ſtate by diſſipating their volatile contents by the blow-pipe on a piece of charcoal. In the large way, they are revived by fuſion with charcoal.

Uſes of lead.

The ores of this metal are abundantly found in the mine counties of England, and in various other parts of the globe. Its uſes are numerous, and ſcarcely need be mentioned. Its calces have been already mentioned as of great uſe as a pigment, and in the manufacture of glaſs. Lead is caſt into thin ſheets for covering buildings, making water-pipes, and various other uſes; and this is rolled between two cylinders of iron, to give it the requiſite uniformity and thinneſs. Lead is thought, and with ſome reaſon, to be not perfectly innocent even for water-

pipes,

LEAD.

ipes, and much leſs ſo for any other kind of veſſels. The workmen in any of the preparations of lead re generally ſubject to a peculiar colic, and paralytic iſorders; which moſt probably ariſe from the inernal uſe of the metal: for it is a fact that theſe workmen are not ſufficiently cautious in waſhing heir hands, or removing ſuch particles of lead, or s preparations, as may caſually intermix with their ood.

CHAP. VI.

CONCERNING COPPER.

COPPER. Characters of copper.

COPPER is a metal of a peculiar reddiſh brown colour; hard, ſonorous, very malleable, and ductile; of conſiderable tenacity, and of a moderate ſpecific gravity. At a degree of heat far below ignition the ſurface of a piece of poliſhed copper becomes covered with various ranges of priſmatic colours, the red of each order being neareſt the end which has been moſt heated; an effect which muſt doubtleſs be attributed to calcination, the ſtratum of calx being thickeſt where the heat is greateſt, and growing gradually thinner and thinner towards the colder part. A greater degree of heat calcines it more rapidly, ſo that it contracts thin powdery ſcales on its ſurface, which may be eaſily rubbed off; the flame of the fuel becoming at the ſame time of a beautiful blueiſh green colour. In a ſtrong white heat, nearly the ſame as is neceſſary to melt gold or ſilver, it melts, and exhibits a blueiſh green flame; by a violent heat it boils, and is volatilized partly in the metallic ſtate.

See Newton's Optics.

Corroſion of copper:

Copper ruſts in the air; but the corroded part is very thin, and preſerves the metal beneath from further corroſion.

— and ſolution in vitriolic acid.

The vitriolic acid, when concentrated and boiling, diſſolves copper. A brown thick fluid, containing calx of copper, and a portion of the calx combined with

COPPER.

th vitriolic acid, is found at the bottom of the vent. If water be added to this, it forms a blue ution of copper, which by evaporation affords blue ſtals, that require about four times their weight water to diſſolve them. This ſolution lets fall a x of copper of a green colour by long expoſure to air.

Vitriolic combinations and precipitates.

The ſolutions of copper in vitriolic acid are ſlightly ıſtic. Magneſia, lime, and the fixed alkalis, preitate the metal from them in the form of calx. latile alkali precipitates all the ſolutions of copper; t rediſſolves the calx, and produces a deep blue lour. Copper is precipitable from moſt of its ſoluns in the metallic ſtate by the addition of iron: a an plate of iron ſoon becomes covered with a coatg of copper when immerſed in the ſolution: hence e volatile alkali, and the application of iron, are conlered as the teſts of the preſence of copper. There e certain mineral waters in Hungary, Sweden, Ireıd, and in various parts of England, which contain riol of copper, and from which it is precipitated by e addition of pieces of old iron.

Nitrous combination of copper.

Nitrous acid diſſolves copper with great rapidity, d diſengages a large quantity of nitrous gas. Part the metal falls down in the form of a calx; and c filtrated or decanted ſolution, which is of a much eper blue colour than the vitriolic ſolution, affords yſtals by ſlow evaporation. This ſalt is deliqueſnt, very ſoluble in water, but moſt plentifully when e fluid is heated. Its ſolution, expoſed to the air ı ſhallow veſſels, depoſits a calx of a green colour. ime precipitates the metal of a pale blue; fixed alkalis,

COPPER.

alkalis, of a blueiſh white. Volatile alkali throws down blueiſh flocks, which are quickly rediſſolved, and produce a lively blue colour in the fluid.

Solution of copper in marine acid:

Marine acid does not readily diſſolve copper, unleſs it be concentrated and boiling. The ſolution is of a deep brown colour; but, on ſtanding for ſome time, it depoſits a ſediment, and becomes green. By careful evaporation it yields cryſtals; or, when inſpiſſated, it affords a greeniſh maſs, which deliqueſces in the air, is readily diſſolved in water, gives a green tincture to ardent ſpirit, melts in a gentle heat, takes fire from a candle, and burns with a blue flame. The marine acid diſſolves the calces of copper more readily than the metal itſelf; but the ſolution does not differ from the foregoing.

— in vegetable acids.

Effect of the preſence of air.

Vegetable acids diſſolve copper ſlowly; but in conſiderable quantity, if reſpirable air be preſent. In this, as in a number of other metallic ſolutions, it appears that the diſpoſition of the air to calcine the metal is greatly aſſiſted by the elective attraction of the acid for the metallic calx. Vinegar does not diſſolve copper when boiling, becauſe the ſteam prevents the acceſs of the air; but the ſame acid ſtanding for a day in a copper veſſel, will contract a dangerous metallic impregnation. This circumſtance accounts for the unhappy conſequences in ſome inſtances attending the uſe of copper veſſels, which in other caſes have produced no noxious effects. Confectioners boil pickles, and even lemon juice, in clean copper veſſels, without obſerving any bad taſte or noxious conſequence to follow. We cannot however avoid heartily concurring in the general opinion which now prevails, s, in the rejection of copper veſſels for culinary oſes.

Fabrication of verdigris.

erdigris is a calx of copper prepared in large tities near Montpellier in France, by ſtratifying er plates with the huſks of grapes which remain the juice has been preſſed out. Theſe ſoon be- e acid, and corrode the copper. A ſolution of calx in diſtilled vinegar affords permanent cryſtals, operly called diſtilled verdigris.

Solution of copper in fixed alkalis:

xed alkalis have ſome action on copper, with h they form a light blue ſolution. This, as as the volatile alkaline ſolution, appears to ed better in the cold than by the aſſiſtance of for the ſame reaſon as the cold acetous acid acts copper; namely, the facility with which the l is calcined by the acceſs of air.

— in volatile alkali.

latile alkali diſſolves copper with much greater ity than fixed alkalis, whether it be in the me- or calciform ſtate; and forms a beautiful ſolution. This fluid has long attracted the of chemiſts, on account of its becoming rleſs in cloſed veſſels; and recovering its co- which gradually extends from the ſurface wards, when the veſſel is opened. This effect lained by the ſuppoſition, that the perfect ſolu- f calx of copper in volatile alkali is colourleſs the alkali is in exceſs; but that it is blue when unds with calx of copper: and accordingly found that the loſs of colour on keeping the cloſed for ſome time, and its re-appearance ening the veſſel, does not ſucceed with old ſo- s, which are permanently blue. The air cal-

cines

Habitudes of copper with volatile alkali:

cines more perfectly a portion of the ſuſpended copper, which gives a blue colour to the fluid until i has more intimately combined with the alkali. I this combination be made in the cloſed veſſel, th colour diſappears; if it be made in the open veſſel the calcination of another portion goes on, and co tinues until the alkali is ſaturated, and can combin with no more: ſo that the laſt portion of perfec calx, which cauſes the blue colour, does not ſeen to have entered into ſo intimate a combination, f want of an exceſs of alkali. The alkali does n take up any conſiderable quantity when applied copper filings; but it diſſolves much more of t calces of copper. The ſolution does not very read afford cryſtals.

— with oils, earths, alkalis, and neutral ſalts.

Oils do not ſeem to act upon copper until th become rancid; in which caſe their diſengaged a corrodes the copper, and the oil aſſumes a blu green colour. Verdigris is ſoluble in ardent ſpi Copper in the metallic ſtate does not unite w earths or alkalis in the dry way: its calces e into the compoſition of glaſs. In general, it d not act on the neutral ſalts by fuſion. Nitre toniates with it but difficultly. Filings of copper thrown upon red-hot nitre; and the reſidue browniſh grey calx, mixed, and partly combi with vegetable alkali. If this be waſhed with ter, the remaining calx may be fuſed, without a addition, into a deep opake brown glaſs, uſe enamellers.

— ſal ammoniac.

Sal ammoniac is decompoſed by copper fil The produce which comes over conſiſts of c

vo

Habitudes of copper with ſal ammoniac:

le alkali, rendered blue by a ſmall portion of
r, together with alkaline air, inflammable air,
hlogiſticated air: the reſidue conſiſts partly of
e ſalt of copper and calx. In this experiment
nd that the copper detains the acid; while
olatile alkali, being ſet at liberty, comes over
he receiver. The inflammable and phlogiſti-
air cannot ſo clearly be accounted for, as they
riſe either from part of the alkali being de-
ſed into its firſt principles; or the inflamma-
r may be ſupplied during the ſolution of the
r; in which caſe it will proceed from the phlo-
of that metal, according to the hypotheſis of
or from a decompoſition of part of the water
ſtallization of the ſal ammoniac; the pure air
ich will be communicated to the copper, in or-
calcine and render it ſoluble in the marine
while its inflammable air comes over in the
ſtate.

— with alum.

olution of alum boiled in a copper veſſel de-
ſome earth; and the fluid exhibits ſigns of the
ce of copper by the teſt of volatile alkali. This
ot ſeem to be a perfect decompoſition of the
but appears to be effected by virtue of the
which that ſalt contains in exceſs. The neutral
alum, ſaturated with its own baſis, falls down,
e leſs ſoluble; while the exceſs of acid, forming
of copper, exhibits the blue tinge when volatile
is added.

— with ſulphur.

per unites very readily with ſulphur. If copper
be mixed with flowers of ſulphur and a little
the combination takes place; but it is much
more

COPPER.

more readily effected in the dry way. This cannot done by direct fuſion, becauſe the ſulphur is burned a much leſs heat than is required to fuſe the copp

Combination of copper with ſulphur:

It may be prepared by mixing equal parts of ſulph and copper filings together, and expoſing them heat, gradually raiſed to ignition: or plates of cop may be ſtratified in a crucible with ſulphur, and g dually heated as before. This compound is a blac grey maſs; and is uſed by dyers and callico printe it is diſtinguiſhed by the name of æs veneris. L of ſulphur diſſolves copper both in the humid dry way.

— with phoſphorus.

Phoſphorus unites with the calx of copper: o the phoſphoric glaſs be expoſed to heat in a cruci together with its weight of copper filings, and a $\frac{1}{4}$ of its weight of charcoal, the phoſphorus w is formed combines with the copper into a kin pyrites, which changes by expoſure to air. It l its metallic ſtate, and aſſumes a black colour.

— with metallic ſubſtances.

The combinations of copper with the metals be treated of have been already mentioned. It u imperfectly with iron in the way of fuſion. Tin readily combines with copper at a temperature m lower than is neceſſary to fuſe copper alone. this is grounded the method of tinning copper ve For this purpoſe, they are firſt ſcraped, or ſcou after which they are rubbed with ſal ammo They are then heated, and beſprinkled with dered reſin, which defends the clean ſurface o copper from acquiring the ſlight film of calx, w would prevent the adheſion of the tin to its ſu The melted tin is then poured in, and ſpread a

COPPER.

tremely ſmall quantity adheres to the copper ;
may with great juſtice be ſuppoſed inſufficient
ent the noxious effects of the copper as per-
s might be wiſhed.

Bronzes and bell-metal.

n tin is melted with copper, it compoſes the
nd called bronze. In this metal the ſpecific
is always greater than would be deduced by
ation from the quantities and ſpecific gravi-
its component parts. The uſes of this hard,
s, and durable compoſition, in the fabrica-
cannon, bells, ſtatues, and other articles,
ll known. Bronzes and bell-metals are not
made of copper and tin only, but have other
res, conſiſting of lead, zinc, or arſenic, ac-
to the motives of profit, or other induce-
of the artiſt. But the attention of the phi-
r is more particularly directed to the mixture
er and tin, on account of its being the ſub-
f which the ſpeculums of reflecting teleſcopes
de. The metal required for this purpoſe
o be capable of an exquiſite poliſh, hard
to receive and retain a figure accurately
o the regular reflection of light, and not
o become tarniſhed by the action of the at-
e. Many excellent teleſcopes have been made
npoſitions of pure copper, alloyed with ſome-
s than half its weight of tin. But it appears
ery well aſcertained, from the obſervations
ſtronomer Royal, that the ſpeculums of Mr.
, whoſe compoſition was the reſult of nu-
trials, are much ſuperior to any which have
made; and are even equal in light to acro-
matic

Metal for ſpeculums.

COPPER.

Edwards's method of making ſpeculums.

matic teleſcopes of the ſame aperture, without al
ing the colours of objects. He firſt melts 32 p
of copper as fluid as poſſible, with one part of br
and one of ſilver, together with the black flux;
the ſame time that fifteen parts of tin are me
in a ſeparate crucible by itſelf. Theſe being ta
from the fire, he pours the tin to the copper;
mediately ſtirs the whole together with a wo
ſpatula, and pours it out haſtily into a large qu
tity of cold water, which cools and granulates
compoſition. If the tin were fuſed together w
the copper, or if they were to remain for any
of time in the extreme heat which is neceſſar
fuſe this laſt metal, a part of the tin would be
cined, and the metal would abound more or
with ſmall microſcopic pores. If one of the p
of the cold metal be broken, it will appear
moſt beautiful bright colour, reſembling quic
Mr. Edwards affirms, that different kinds of co
require different doſes of tin to produce the
perfect whiteneſs. If the doſe of tin be too
which is the fault moſt eaſily remedied, the
poſition will be yellowiſh; if it be too grea
compoſition will be of a grey blue colour, and
appearance. He therefore finds by trial the qu
of tin neceſſary to be added in the ſecond fuſi
render the metal the moſt perfect. A much
degree of heat is then required to melt the
pound. In the ſecond melting he adds one p
arſenic, and immediately ſtirs the mixture;
he pours into the mould as ſoon as the fu
the arſenic have ceaſed to riſe. He caſts th

Metallic mixtures.

m in ſand, with the face downwards; takes it while red-hot, and places it in hot wood aſhes ool; without which precaution it would break in ing*.

opper unites with biſmuth, and forms a reddiſh e alloy. With arſenic it forms a white brittle pound, called tombac. With zinc it forms the pound called braſs, and diſtinguiſhed by various r names, according to the proportions of the ingredients. It is not eaſy to unite theſe two ls in conſiderable proportions by fuſion, becauſe zinc is burned or volatilized at a heat inferior to which is required to melt copper; but they unite well in the way of cementation. In the braſs s, copper is granulated by pouring it through a of iron, perforated with ſmall holes and luted clay, into a quantity of water about four feet , and continually renewed: to prevent the dan- ıs exploſions of this metal, it is neceſſary to pour ı ſmall quantity at a time. There are various ods of combining this granulated copper, or other pieces of copper, with the vapour of zinc. nine, which is an ore of zinc, is pounded, and

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ls the conſtruction of teleſcopes is foreign to the immediate ſe of this work, it has not been thought neceſſary to men- he ſeveral precautions of Mr. Edwards in this buſineſs; e curious operator, who may wiſh to undertake the con- on of a reflecting teleſcope (the better kinds of which ot only difficult to be procured, but of conſiderable price), ave recourſe to Edwards's Treatiſe, annexed to the Nau- lmanack for 1787; where he will find ample inſtructions at purpoſe.

The fabrication of braſs.

mixed with the divided copper, together with a portion of charcoal. Theſe being expoſed to the heat of a wind furnace, the zinc becomes revived, riſes in vapour, and combines with the copper, which it converts into braſs. The heat muſt be continued for a greater or leſs number of hours, according to the thickneſs of the pieces of copper, and other circumſtances; and at the end of the proceſs the heat, being ſuddenly raiſed, cauſes the braſs to melt, and occupy the lower part of the crucible. The moſt ſcientific method of making braſs ſeems to be that mentioned by Cramer*. The powdered calamine, being mixed with an equal quantity of charcoal, and a portion of clay, is to be rammed into a melting veſſel; and a quantity of copper amounting to two thirds of the weight of the cala mine, muſt be placed on the top, and covered wit charcoal. By this management the volatile zin aſcends, and converts the copper into braſs, whic flows upon the rammed clay: conſequently, if th calamine contain lead, or any other metal, it wi not enter into the braſs, the zinc alone being raiſe by the heat.

Leaf braſs, or Dutch gold.

A fine kind of braſs, which is ſuppoſed to be ma by cementation of copper plates with calamine, hammered out into leaves in Germany; and is so very cheap in this country, under the name of Dut gold. It is, as I find, about five times as thick gold leaf; that is to ſay, it is about one ſixty-tho ſandth of an inch thick.

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* Art of Aſſaying Metals. London, 1764. Page 377

Metallic mixtures.

braſs be kept in a ſtate of ignition, with contact ir, the zinc burns, and the copper remains. ther the zinc would quit the braſs without com- on, is not known; though there is little doubt t might be driven off in cloſe veſſels.

ıe quantity of zinc in good braſs is about one of its weight.

pper unites readily with regulus of antimony; affords a compound of a beautiful violet colour. oes not readily unite with manganeſe. With am it forms a dark brown ſpongy alloy, which newhat ductile.

Native copper, and its ores.

pper is either found native, moſtly in an im- ſtate; or in the form of a calx, of a red, ı, or blue colour. The native ſolutions of cop- requently impregnate calcareous earths, in which depoſit the metal. The turquoiſe ſtone is the of an animal, penetrated with the blue calx of r. Many ores of copper contain ſulphur. ıg theſe, the vitreous copper ore is of a red, n, blue, or violet colour; ſometimes cryſtal- but uſually ſoft enough to be cut with a knife. of the pyrites contain a conſiderable propor- of copper, together with iron, ſulphur, and The grey copper ore is a ſulphureous com- on, containing arſenic: it is of a white, grey, rown colour, heavy, and difficult of fuſion. loſe copper ore is of a brown colour, hard, compact, and granulated: it contains the me- vith ſulphur, arſenic, zinc, and iron. Some and one ſpecies of coal, afford copper; and

ſeveral waters contain this metal, diſſolved in vitriolic
or marine acid.

Aſſay of native copper:

Native copper may be aſſayed in the humid way
by ſolution in nitrous acid. If it contain gold, this
metal falls untouched to the bottom, in the form of
a black powder; if ſilver, it is ſoon precipitate
by more copper; if iron, by boiling the ſolution fo
ſome time, it is gradually calcined, and falls to th
bottom.

— of calciform ores:

The calciform copper ores are ſoluble in acids, an
may be precipitated either by iron, which affords th
copper in the metallic ſtate; or by mild alkali, whic
throws down 194 grains of precipitate for every 10
grains of copper.

— of ſulphureous ores:

Sulphureous copper ores may be powdered, an
gently boiled to dryneſs in five times their weig
of concentrated vitriolic acid. The whole, or m
part of the ſulphur, flies off by this heat. T
vitriolic ſalt of copper requires at leaſt four tim
its weight of water to diſſolve it. A ſufficient qua
tity being therefore added, and a poliſhed iron pl
boiled in the ſolution, the copper will be preci
tated. If iron be found to be mixed with the p
cipitate, it muſt be again diſſolved, to obtain a rich
ſolution. This will depoſit pure copper, if the o
ration be conducted as before. If it contain oth
metals, they may be eaſily ſeparated by ſolution
nitrous acid.

— in the dry way.

In the dry way, the ſulphureous ores of cop
muſt be firſt pulverized, and ſeparated as much
poſſible from the earthy and ſtony particles; t

roa

aſted, to ſeparate the ſulphur and arſenic; and, ſtly, melted with an equal weight of M. Tillet's x, which conſiſts of two parts of pounded glaſs, e calcined borax, and ⅛ of charcoal. More borax ay be added if the ore be poor. Alkaline fluxes are rtful in the fuſion of copper ores, becauſe the ſalt mbines with the ſulphur, and forms hepar, which ſolves part of the copper.

Treatment of copper ores in the large way.

In the large way, copper is roaſted in a cloſe fur- ce, by a ſlow fire, to ſcorify the mixtures of iron, d other ſubſtances. By repeated fuſions with ſul- ur and charcoal, the ſcorified metal riſes to the top, d is ſcummed off. The copper in the great Hun- rian mines is ſaid to undergo fuſion fourteen times fore it is fit for ſale. The roaſted ore in the iſle Angleſey is deprived of its vitriolic ſalt by waſh- ; and the copper is precipitated by means of old n immerſed in the water. This precipitated cop- r is, however, but a ſmall proportion of the whole duce.

Countries where copper is found.

Copper is found in various parts of the world; in ain, France, England, Norway, Hungary, Swe- n, and elſewhere. The Japan copper is ſaid to be rer, and has a greater ſpecific gravity, than any er copper. The wire-drawers, who require cop- of extraordinary ductility, uſe the Swediſh cop- . The copper mines in England are exceedingly merous and productive. Paris mountain, on the of Angleſey, contains a bed of ore forty feet thickneſs; and is ſaid to produce upwards of four uſand tons of copper annually.

COPPER.

Copper applied to various uſes.

The uſes of this metal are too numerous to be diſtinctly ſpecified. It has for ſome years paſt been applied with great ſucceſs and advantage, for ſheathing the bottoms of ſhips; and ſeveral builders have lately endeavoured to introduce it as a covering for houſes. It is the lighteſt of all coverings; but whether it be more durable than ſlate, which is nearly as light, has not yet been aſcertained by experience.

CHAP. VII.

CONCERNING IRON.

IRON.

Characters of iron.

ON is a metal of a blueiſh white colour, of con-
iderable hardneſs and elaſticity; very malleable,
edingly tenacious and ductile, and of a moderate
ific gravity among metallic ſubſtances. It is much
oſed to ruſt by the acceſs of air, or the action of
er, in the common temperature of the atmoſphere.
appearance of priſmatic colours on its poliſhed
ace takes place long before ignition; and at ſo
a temperature, that the ſlighteſt coating of greaſe
fficient to prevent their appearance, by defending
om the contact of air. It may be ignited, or
aſt rendered ſufficiently hot to ſet fire to brim-
e, by a quick ſucceſſion of blows with a hammer.
n ſtruck with a flint, or other hard ſtone, it
s decrepitating ignited particles, ſuch as can be
ned from no other metal by the ſame means.
e particles are ſeldom larger than the two
lredth part of an inch in diameter; and, when
ined by a magnifier, are found to be hollow,
e, and of a greyiſh colour, reſembling the ſcales
urned iron. This metal is eaſily calcined by fire.
ece of iron wire, immerſed in a jar of vital air,
ignited at one end, will be entirely conſumed
e ſucceſſive combuſtion of its parts. It requires
ſt intenſe heat to fuſe it; on which account it
nly be brought into the ſhape of tools and uten-

Characters of iron.

ſils by hammering. This high degree of infuſibility would deprive it of the moſt valuable property of metals, namely, the uniting of ſmaller maſſes into one, if it did not poſſeſs another ſingular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat iron appears as if covered with a kind of varniſh; and in this ſtate, if two pieces be applied together, they will adhere, and may be perfectly united by forging. Iron is thought to be the only ſubſtance in nature which has the property of becoming magnetical. It is highly probable, from the great abundance of this metal, that all ſubſtances which exhibit magnetiſm do contain iron; but it muſt be confeſſed that there remain many experiments to be made among the earths and powders which exhibit magnetical properties, before this negative propoſition which confines magnetiſm to iron, can be admitted as proved.

Calcination of iron by water.

When iron is expoſed to the action of pure water it acquires weight by gradual calcination, and in flammable air eſcapes: this is a very ſlow opera tion. But if the ſteam of water be made to paſ through a red-hot gun-barrel, or through an ignite copper or glaſs tube containing iron wire, the iro becomes converted into a calx; while inflammabl air paſſes out at the other end of the barrel. Th capital experiment * may be accounted for accordin to the ancient and modern theories. In the ancie theory, it is ſuppoſed that the water has combine with the iron, and diſengaged its phlogiſton in th

Ancient theory.

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* Of M. Lavoiſier.

Calcination of iron by water.

rm of inflammable air; and conſequently that,
en this calx is again revived by heating a portion
it in inflammable air with a burning glaſs, and
ter appears, at the ſame time that part of the
lammable air is abſorbed, the iron has imbibed
logiſton, and given out its water. Clear as this
planation appears to be, the ſolution afforded by
e modern theory is not leſs perſpicuous. The
intainers of this theory reaſon as follows: Iron has
t been ſhewn to be a compound ſubſtance; let us
erefore conſider it as a ſimple ſubſtance, until we
ſſeſs experiments which ſhew the contrary. Water
s been ſhewn to be a compound ſubſtance, by the
periment of its production, by burning dephlogiſti-
ted and inflammable air together. We may fairly
erefore affirm, that the inflammable air came from
e water, in which we know it to exiſt; and that
e vital air of the water, the peculiar inſtrument of
lcination, has combined with the iron. On the
her hand, when the iron is revived in inflammable
r, the water which appears is the very product of
mbination which was decompoſed in the former
ſtance. For the vital air quits the iron to unite
the fluid ſtate with the inflammable air; and the
on, being ſet at liberty, recovers its original ſtate;
at is to ſay, it is revived.

Modern theory.

See page 95.

Page 93. 131.

Difficulty.

That the iron, in the one inſtance, attracts vital
r from the water, and diſengages inflammable air;
nd, in the other inſtance, exhibits a leſs affinity with
at ſubſtance, ſo as to reſtore it to its former com-
ination; is a difficulty which, in the preſent ſtate of
ur information, can only be accounted for by ſup-

IRON.

Calcination of iron by water.

poſing, that the temperature in the furnace differs from that produced by the burning glaſs; and that theſe affinities, like moſt others in chemiſtry, are not the ſame at all temperatures. This difficulty affects both theories alike; for it is not eaſier to account for the contrary tranſitions of water and phlogiſton, which mutually expel each other in the old theory, than for the tranſitions of dephlogiſticated and inflammable air in the new theory.

Theory.

The philoſophers who reject phlogiſton inſiſt, moreover, that the weight of the inflammable air produced, being deducted from the weight of the wate made uſe of, leaves a quantity equal to the increaſ the iron gains by calcination; and that by burnin the whole inflammable air produced, with a quantit of vital air equal in weight to the gain of the iron, new quantity of water is recompoſed, which is equa likewiſe to that made uſe of. Hence they urge, tha it is infinitely more probable that the inflammabl air came from the water than from the iron. Th latter fact, of the recompoſition, is in their favour but the former is not. For whatever the inflammable air comes from, the firſt equation will be true that is to ſay, if the iron give out phlogiſton, an receive water, its acceſſion of weight will be equ to the difference between the water it has receive and the phlogiſton it has loſt; but the reproductio of the water loſt will ſhew that the inflammable a really correſponds with the quantity required to form

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[*] It may be urged that the two airs contain much wate and for that, as well as other reaſons, their abſolute quantit cann

much water, if we admit the accuracy of the eriments.

Solution of iron in the vitriolic acid.

'he concentrated vitriolic acid ſcarcely acts on ı, unleſs it be boiling. When the acid is diſtilled lryneſs from this metal, the retort is found to con- ı ſublimed flowers of ſulphur, and a white vitriolic 's, partly ſoluble in water: the product which ıes over is volatile vitriolic acid, and vitriolic acid If the vitriolic acid be diluted with two or three :s of water, it diſſolves iron readily, without the tance of any other heat than is produced by the act combination. During this ſolution, inflammable eſcapes in large quantities. If heat be applied, acid proceeds to diſſolve more iron, and depoſits hite ſaline maſs, or pale vitriol of iron.

Martial vitriol.

'he combination of vitriolic acid and iron, called tial vitriol, is much more ſoluble in hot than cold er; and therefore cryſtallizes by cooling, as well y evaporation. The cryſtals are effloreſcent, and

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ɔt be aſcertained. But it is not required to aſcertain their ute quantities: for it is enough if the two airs in this npoſition be exactly in the ſame ſtate as in the original riment, by which the component parts of water were deter- d. If a certain portion of water be neceſſary to inflamma- ir in the elaſtic ſtate, it muſt of courſe take it from the ſteam ıe gun-barrel at the inſtant of its extrication, and not after- s from the water of the receivers: this requires to be rmed by an experiment over mercury. How far Dr. Prieſt- experiments (Phil. Tranſ. lxxviii. and lxxix.) may affect ɔoſition, that water is a compound ſubſtance, cannot be clearly tained until it is ſhewn that the acid produced in burning two airs does not ariſe from impurity in one or both of . See page 95.

Martial vitriol.

fall into a white powder by expoſure to a dry air, the iron becoming more calcined than before. A ſolution of martial vitriol, expoſed to the air, imbibes its vital part; and a portion of the iron, becoming too much calcined to adhere to the acid, falls to the bottom in the form of ochre. The ſolution, as well as the cryſtals it affords by evaporation, are thus rendered paler than before.

Page 140.

Martial vitriol is not made in the direct way, be cauſe it can be obtained at leſs charge from the de compoſition of martial pyrites.

Theory of the effects of vitriolic acid upon iron; according to the doctrine of phlogiſton.

The different appearances which accompany the ſolutions of iron in the vitriolic acid, may be accoun ed for according to the principles either of the an cient or modern theories. In the ancient theory, iron being ſuppoſed to contain phlogiſton, or the principle of inflammability, is calcined in both caſes; that i to ſay, it gives out phlogiſton [*]. With the concen trated acid the ſolution does not take place; becauſ the capacity of the mixture for heat, and conſequentl its abſolute quantity of heat, is too ſmall to ſupply wha the increaſed capacity of the vitriolic acid air woul require, and conſequently the iron is not decompoſe But when heat is applied, the phlogiſton of the iro uniting with the baſis of part of the acid, forms ſu phur; which, together with another portion of t acid, riſes in the form of vitriolic acid air; at th ſame time that the vital air of the decompoſed ac unites with the calx of iron, which becomes ſolub

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[*] Kirwan, in Philoſ. Tranſact. vol. lxxii; and Eſſay Phlogiſton, London, 1789, page 62, or page 28 of the c edition.

I

IRON.

Theory:

he acid that remains: but when much water is ent, as in the diluted acid, the heat is ſupplied the great capacity of the water; the phlogiſton e iron aſſumes the claſtic form; and inflamma- ir flies off, while the acid unites with the calx on, and forms vitriol. The decompoſition of the in the former, and not in the latter caſe, is ac- ted for from its ſtrong attraction to the water. nſiderable heat, applied with the diluted acid, nes the iron more perfectly; which then either rs into the compoſition of pale vitriol, containing ger proportion of acid, or falls down in the form alx. The acceſs of air does the ſame thing more ually.

— according to the antiphlogiſtic doctrine.

the antiphlogiſtic theory, iron is aſſumed to be a le ſubſtance; vitriolic acid is ſaid to be compoſed ital air and ſulphur; and water is admitted to be mpoſable. When iron therefore is applied to entrated vitriolic acid, the principles retain their r of combination at a common temperature; but on as the temperature is raiſed, the iron becomes ned, by attracting vital air from part of the acid, ſe ſulphur is therefore ſet at liberty, and flies rith another portion of the acid, in the form of lic air; while the remaining acid combines with of the calx. But when the acid is more diluted, vater itſelf is decompoſed; its inflammable air is gaged; its vital air unites with and calcines the ; and the vitriolic acid diſſolves the calx.

he neceſſity of heat being applied to the concen- d ſolution in the one caſe rather than the other, be referred to the capacities of the bodies, before and

Theory of the action of vitriolic acid on iron.

and after the change, in either theory. But it muſt be confeſſed that the cauſe of the diſengagement of vitriolic air in the one caſe, and inflammable in the other, is not ſo well ſolved. It has not been explained, upon the old theory, why the phlogiſton in one caſe unites with the acid, and forms ſulphur, and in the other flies off alone; neither has it been ſhewn, in the new theory, why the water ſhould not be decompoſed in the former inſtance, as well as the latter.

The further calcination of the iron by heat, or by expoſure of the ſolution to the air, is accounted for, in the new theory, from the abſorption of more vital air. The general fact, that a definite degree of calcination is neceſſary for the moſt perfect ſolution of metals in acids, depends on attractions which have not been experimentally reſolved; but which, in the way of conjecture, may be as eaſily accounted for by one theory as by the other.

Precipitates of iron.

Vitriol of iron is decompoſed by alkalis and by lime. Cauſtic fixed alkali precipitates the iron in deep green flocks, which are diſſolved by the addition of more alkali, and form a red tincture. The mild alkali does not rediſſolve the precipitate it throws down, which is of a greeniſh white colour. Diſtillation ſeparates the acid from martial vitriol, and leaves the brown calx of iron, called colcothar.

Colcothar.

Black fecula, precipitated by aſtringents.

Vegetable aſtringent matters, ſuch as nut-galls, the huſks of nuts, logwood, tea, &c. which contain the acid of galls hereafter to be deſcribed, precipitate a fine black fecula from martial vitriol, which remains ſuſpended for a conſiderable time in the fluid, by the addition of gum arabic. This fluid is well known by

th

IRON.

Ink; its nature doubtful.

ame of ink. It appears to conſiſt of the acid of
united to the calx of iron: but its nature has
een well determined; more eſpecially by an ex-
ation of the contents of the fluid which remains
the precipitate has been completely depoſited.
black fecula is not magnetical; but it is con-
d into a brown magnetic calx by heat. An ex-
f either of the three ancient mineral acids ren-
ink colourleſs; but the acetous acid, or vinegar,
not. Ink becomes blacker by expoſure to the
which acidifies more completely the principle
ined with the iron; but ancient writings become
and more yellow, in conſequence of the eſcape
e acid *. Their legibility may be reſtored by the
ion of infuſion of galls, or gallic acid. The beſt
od of reſtoring the legibility of ancient writ-

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nks ſeem to fail chiefly on account of the ſmall proportion
ſtructibility of the aſtringent principle, or gallic acid. Dr.
recommends the following receipt for writing-ink (Com-
of Arts, page 391): One part martial vitriol, one part
red logwood, and three parts powdered galls, are to be
d in one quart of vinegar, or white wine, or water, for
unce of the vitriol, together with one ounce of gum ara-
r each quart of the liquor; and ſhaken for four or five
a day, during ten or twelve days: after which it may be
ed for uſe.

the above I muſt remark, that though vinegar affords a good
ink, yet Dr. Lewis has overlooked a great inconvenience
ing its uſe. It acts ſo ſtrongly upon the quills, that the
eſs of the extremity of a pen uſed with this ink ſoon
ff, and continually wants mending. A perfect theory of
ould probably lead to great improvements in this moſt
fluid.

Manufacture of Pruſſian blue.

ings * conſiſts in ſpreading a ſolution of the Pruſſia alkali thinly with a feather over the traces of t letters; and then to touch it gently, and as nearl upon or over the letters as can be done, with a dilut acid, by means of a pointed ſtick.

The beautiful pigment, well known in the arts the name of Pruſſian blue, is likewiſe a precipita afforded by martial vitriol. It has been made for co ſiderably more than half a century; but its comp ſition is not yet clearly aſcertained. The proceſs making it is as follows: Calcine a mixture of eq parts of vegetable alkali and dried bullocks bloo until it ceaſes to emit either flame or ſmoke; th raiſe the fire, to give the maſs a low red he Throw the matter while red-hot into as many qua of water as there were pounds of the original mixtu and boil it for half an hour. Decant the liquid, a waſh the coaly reſidue with more water, till it comes almoſt inſipid. Add this water to the former, a evaporate the whole by boiling, until it be redu again to the former number of quarts. This is

Pruſſian alkali.

lixivium ſanguinis, or Pruſſian alkali; which, if ad in a proper quantity to a ſolution of iron, precipit it partly in the form of calx, and partly in the fo of Pruſſian blue. If the marine acid be added to precipitate, it diſſolves the calciform part, and lea the Pruſſian blue much purer. Hence it appears the whole of the alkali, in the uſual method of cination with bullocks blood, or other animal ſtances, is not ſaturated with the colouring matter,

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* Blagden, in Philoſ. Tranſ. vol. lxxv. page 455.

t the unſaturated part of the alkali precipitates part the iron in the calciform ſtate; while the other t, combining with the colouring matter, falls down the form of Pruſſian blue. For chemical purpoſes, Pruſſian lye is produced, by boiling the alkali upon ſſian blue ready formed. The calx of iron is thus rived of the colouring matter by the alkali, to ich it has a greater affinity, and which it only quits en there is another acid preſent to unite with the ali; as in the juſt-mentioned inſtance of the ſolu- of iron, where a double affinity takes place. The ſſian alkali, prepared in either way, contains ſome . It can be had pure in no other way than by ctly combining the pure colouring matter with a e alkali.

Pruſſian alkali made for chemical purpoſes.

he habitudes of this colouring matter denote it e an acid. If the Pruſſian alkali be boiled in a rt with weak vitriolic acid, the colouring matter es over in the form of an inflammable air, which l be abſorbed by water placed in the receiver. a portion of vitriolic acid likewiſe comes over, a nd diſtillation is neceſſary to be made, with the ition of chalk. The vitriolic acid, by this means ming ſelenite, is detained; while the Pruſſian acid ſes over totally before one-fourth of the water is illed off.

Acid of Pruſſian blue.

he colouring matter of Pruſſian blue is not only zed by the fixed alkalis, but likewiſe by the volatile ali, by lime; by magneſia, and by ponderous earth; th which it forms peculiar compounds, capable of cipitating Pruſſian blue, by double affinity, from the utions of iron in acids. Various metals likewiſe com-

Combinations of Pruſſian acid.

Caution in uſing proof liquors.

combine with it. Alkalis, or lime, combined with the Pruſſian acid, are uſed as teſts to aſcertain the preſence and quantity of iron in ſolution. But all the alkaline or earthy combinations, produced by applying thoſe ſubſtances to Pruſſian blue, contain iron, which falls down in the form of the blue precipitate when an acid is added. For this reaſon they cannot be uſed in accurate experiments, unleſs a previous trial has been made of the quantity a known proportion of the proof liquor is capable of precipitating.

Experiments on Pruſſian acid.

If the dephlogiſticated or aërated marine acid be mixed with the Pruſſian acid, the former reſume the ſtate of common marine acid; while the latte acquires a much ſtronger ſmell, and appears to b more volatile. In this ſituation it does not form Pruſſian blue with the ſolutions of iron; but afford a green precipitate, which becomes blue by expoſu to the light, or by the addition of volatile vitrioli acid.

If martial vitriol be added to the dephlogiſticate or aërated marine acid, and a ſolution of Pruſſia alkali be poured in, the green precipitate which formed is again diſſolved; but it may be precipitate of a blue colour by the addition of volatile vitriol acid, or martial vitriol, or iron alone.

Theory.

In the inſtances laſt mentioned we may percei that the effects depend on the dephlogiſtication or ad dition of vital air to the Pruſſian acid, according as we adopt the ancient or the modern theory. Th green precipitate, which may be conſidered eith as dephlogiſticated Pruſſian blue, or as Pruſſian bl combined with vital air, becomes common Pruſſi

bl

Page 89, 168, 178.

by the action of light; which, as we have fre-
tly had occaſion to remark, operates in many
nces in a manner contrary to that of combuſ-
; that is to ſay, it either adds phlogiſton, or ex-
vital air, or does both. By this action there-
the Pruſſian blue returns to its original ſtate.
addition of volatile vitriolic acid muſt produce a
effect; for this acid is phlogiſticated according to
ld theory, or is deficient in vital air according
e new: it is therefore diſpoſed either to phlogiſ-
e the green precipitate, or to attract vital air
it; which is all that it requires to convert it into
non Pruſſian blue. The ſame theories manifeſtly
to the green precipitate, which is rediſſolved;
whatever ſtate of combination it may be ſup-
l to remain, as to the order or arrangement of
rinciples which are united in the fluid, the addi-
of volatile vitriolic acid, or common vitriol,
on in the metallic ſtate, will impart phlogiſton,
tract vital air; the abſence of the one, or re-
ance of the other of which, is ſuppoſed, accord-
o the reſpective theories, to cauſe the difference
en it and Pruſſian blue.

Theory of the effects of aerated marine acid on Pruſſian acid.

Experiment.

the Pruſſian acid be impregnated more ſtrongly
the dephlogiſticated or aërated marine acid, and
expoſed to the action of light, it aſſumes new
rties. It no longer combines with iron precipi-
from its ſolutions; its ſmell is entirely different
that which it before poſſeſſed; and now reſembles
omatic oil, the greateſt part of it ſeparating from
ater, at the bottom of which it flows in the
of an oil. This fluid however is not inflam-

IRON.

mable. By a gentle heat it riſes in the form of a vapour, not ſoluble in water: and in time it aſſume the form of ſmall cryſtals. Pruſſian acid cannot b reſtored after it has undergone theſe changes. Thei theory is not known.

Diſcovery of the component parts of Pruſſian acid.

Various experiments have been made to diſcove the component parts of the Pruſſian acid. If equ parts of pulverized charcoal and vegetable alkali b made red-hot for a quarter of an hour in a crucibl and ſome ſal ammoniac in ſmall pieces be th briſkly ſtirred down into the maſs, the ammoniac vapours will ſoon ceaſe. The ignited matter bei then thrown into water, affords a lixivium equal the beſt which is made with blood. From theſe, a other experiments, it was concluded that its com nent parts are fixed air, volatile alkali, and the pr ciple of inflammability, or phlogiſton. Later exp ments appear to have decided the queſtion ſomew more accurately. When the acid has been conver by means of the dephlogiſticated or aërated ma acid, into that ſtate which affords a green precip with iron, it emits alkaline air upon the additio lime, or a pure alkali. If the lime, or alkali, be a wards ſaturated by the addition of ſome other the Pruſſian acid is not diſengaged, or reſtored, is no where found; hence it follows, that the alk air was one of the principles of the Pruſſian which is deſtroyed: and as the lime or alkali in this decompoſition is found to be in a mild that is to ſay, combined with fixed air, thou did not contain that ſubſtance before; it is clea the other principle of the Pruſſian acid is fixe

Component parts of Pruſſian acid.

e common Pruſſian acid conſiſts therefore of vo-
le alkali, united with the baſe of fixed air, or that
ſtance which, in combination with vital air, forms
acid called fixed air. When the Pruſſian acid
eives vital air, and is converted into the ſtate pro-
to afford the green precipitate, it then appears to
ſiſt of the ſame principles as the mild or concrete
tile alkali, though probably in a different order
combination; and this order ſeems to be deranged
the addition of the lime, or the fixed alkali, which
acts thoſe principles that form fixed air, at the
e time that the principles which form volatile
li fly off in the elaſtic ſtate.

he component parts of Pruſſian acid will conſe-
ntly be phlogiſticated air, inflammable air, and
d air, or its baſe; all which are afforded by animal
ſtances: but they do not form this peculiar com-
ation in any caſe yet known, excepting that in
ch an alkali is preſent when thoſe ſubſtances are
mpoſed by fire *.

Action of nitrous acid on iron.

oncentrated nitrous acid acts very ſtrongly upon
filings, much nitrous air being diſengaged at the
e time. The ſolution is of a reddiſh brown, and
oſits the calx of iron after a certain time; more
cially if the veſſel be left expoſed to the air. A
ted nitrous acid affords a more permanent ſolution

For a fuller account of this ſubject conſult Scheele's Eſſays;
puſcula, or Chemical Eſſays, of Bergman; and the Annales
himie, vol. i; the latter of which contains an abſtract of a
able memoir of Berthollet, read before the Royal Academy
ciences at Paris, in the year 1787.

IRON.

of iron, of a greeniſh colour, or ſometimes of a yellow colour: neither of the ſolutions affords cryſtals but they depoſit the calx of iron by boiling, at the ſam time that the fluid aſſumes a gelatinous appearanc This magma, by diſtillation, affords fuming nitrous acid much nitrous air, and ſome phlogiſticated air; a re calx being left behind, which, in all probability, retai moſt of the vital air of the acid.

Precipitates of iron from nitrous acid.

Martial alkaline tinctures.

If vegetable alkali be added to the nitrous ſolutio of iron, a brown precipitate falls down; of which ſmall quantity is rediſſolved by the alkali. Mild v getable alkali ſeparates a yellowiſh calx, which ſo becomes of a beautiful orange red colour. If th mixture be agitated during the efferveſcence, the p cipitate is rediſſolved in much greater quantity than the pure vegetable alkali; doubtleſs by the mediu of the fixed air. This ſolution is known by the na of Stahl's martial alkaline tincture, and is of a f red colour, which however is impaired by tin Pure volatile alkali ſeparates a deep green and moſt black precipitate from the nitrous ſolution iron. The mild volatile alkali rediſſolves the ir which it ſeparates from the acid; and forms an kaline tincture of a more lively colour than that Stahl.

Action of marine acid on iron.

Diluted marine acid rapidly diſſolves iron, at ſame time that a large quantity of inflammable is diſengaged, and the mixture becomes hot. In t as well as in the vitriolic ſolution of iron, the ſ quantity of alkali is ſaid to be required to ſatu the acid as before the ſolution; whence it is infe that the acid is not decompoſed, but that the calc

n is effected by the vital air of the water : whence
it appears to follow, that the inflammable air
ſt be afforded from the decompoſed water, and not
m the metal. It muſt however be remarked, that
s fact, as well as moſt of thoſe upon which the
ection of phlogiſton, or the inflammable principle,
rounded, are controverted by the philoſophers who
intain the exiſtence of that principle.

Marine ſolution of iron.

The marine ſolution of iron is of a yellowiſh green
our, and is much more permanent than the ſolu-
ns of that metal in the vitriolic or nitrous acids ;
ugh, like all the other ſolutions of iron, it depoſits
metal by expoſure to the air. By evaporation it
umes the conſiſtence of ſyrup, in which needle-
med and deliqueſcent cryſtals appear. Some che-
ts affirm, that the acid quits the iron by diſtilla-
n, though much more difficultly than either the
ous or vitriolic acid ; but this intereſting expe-
ent has not been made ſince the improvements of
miſtry have led philoſophers to attend to ſuch pro-
ts as appear in the permanently elaſtic ſtate.

Precipitates.

The marine ſolution of iron is decompoſed by
e and by alkalis ; but the precipitates are more
ily reduced to the metallic ſtate than thoſe afforded
other acids. Liver of ſulphur, hepatic air, and
ringents, decompoſe this, as well as the other ſo-
ions of iron ; and the pure Pruſſian alkali throws
wn a very fine blue precipitate.

Action of fixed air on iron : —and vinegar.

Fixed air, diſſolved in water, combines with a con-
erable quantity of iron, in proportion to its maſs.
negar ſcarcely diſſolves it, unleſs by the aſſiſtance of
air.

IRON.

Action of earths, &c. on iron.

In the dry way, this metal does not combine with earths, unleſs it be previouſly calcined; in which caſ it aſſiſts their fuſion, and imparts a green colour t the glaſs. It appears to combine with alkalis by fu ſion. Nitre detonates ſtrongly with it, and become alkalized. Sal ammoniac is decompoſed by it. Tw parts of iron filings, triturated with one part of ſ ammoniac, and expoſed to diſtillation, afford abou one part of liquid volatile alkali, contaminated by ſmall portion of iron. Some inflammable air com over in this diſtillation, either from the iron, or fro the water contained in the ſal ammoniac: the reſid conſiſts of iron, united to marine acid. A medic preparation is made by ſubliming ſal ammoniac fro a ſmall portion of iron filings; which gives part the ſalt a yellow colour. The calx of iron decompo ſal ammoniac by ſeizing its acid, even in the cold.

Combination of iron with ſulphur in the humid way.

Sulphur combines very readily with iron, in the d and even in the humid way, though neither of th ſubſtances is ſcarcely at all ſoluble in water. mixture of iron filings and flowers of ſulphur bei moiſtened, or made into a paſte, with water, becom hot, ſwells, adheres together, breaks, and emits w tery vapours of an hepatic ſmell. If the mixture conſiderable in quantity, as for example, one hund pounds, it takes fire in twenty or thirty hours,

Spontaneous inflammation.

ſoon as the aqueous vapours ceaſe. This effect m be explained without difficulty in a general w though the circumſtances require to be more minut examined:—Iron, ſulphur, and water, are placed contact. The iron is very ſparingly ſoluble in wate

* Annales de Chimie, vol. i. 220.

IRON.

Page 136.

Theory of the inflammation of iron and fulphur:

d the fulphur is probably foluble in a fmall degree, may be judged by its becoming foft in that fluid. the ancient theory, it may be faid that the fulphur mbines with the calx of the iron, and expels its lammable air or phlogifton. The heat muft be de- ced, in any theory, from the change of capacity, or id commotion, produced in the act of union. This at volatilizes part of the fulphur, together with the lammable air; and if the temperature be fufficiently vated, thefe fubftances will take fire, at the moment their extrication, by the affiftance of the air of the nofphere. In the new theory, the explanation will nearly the fame. The iron and the fulphur, being nfidered as fimple fubftances, tend to combine with ch other, through the medium of vital air, which cines the iron, and is fuppofed to be afforded by compofition of the water. The fame decompofition tricates inflammable air from the water. This, to- ther with the fulphur, forms hepatic air; which, ing off at the temperature of ignition, takes fire combination with the air of the atmofphere. In is theory it may further be added, that, as fulphur d water, in contact, at an elevated temperature, ord inflammable air, which is explained by the fup- fition of vital air combining with the fulphur, there ould be an increafe of inflammation from this caufe. me doubt however may be entertained, whether lphur be more combuftible than inflammable air at y temperature, fince hepatic air depofits fulphur hen detonated with vital air; which muft, in all obability, depend on the latter being lefs com- ftible at the temperature of inflammation. On the

— by the antiphlogiftic hypothefis.

whole it appears, that facts and obſervations are
wanting, rather than probable theories; and that it is
ſcarcely neceſſary to purſue this inquiry more minutely in the way of argumentative diſquiſition. The
ſpontaneous combuſtion of iron and ſulphur with water, is evidently an effect of the ſame kind as th
decompoſition of pyrites.

Page 140.

Union of ſulphur with iron in the dry way.

Sulphur combines very readily with iron by fuſion;
and produces a compound of the ſame nature a
the pyrites, and exhibiting the ſame radiated ſtructur
when broken. If a bar of iron be heated to white
neſs, and then touched with a roll of ſulphur, th
two ſubſtances combine, and drop down together i
the fluid ſtate. It is neceſſary that this experimen
ſhould be made in a place where there is a current o
air to carry off the fumes; and the melted matte
which may be received in a veſſel of water, is of th
ſame nature as that produced by fuſion in the con
mon way, excepting that a greater quantity of ſu
phur is fuſed by the contact of the bar of iron. Th
experiment of combining iron and ſulphur togeth
by fuſion, has not been made with an attention t
the volatile products, if any be extricated. As ne
ther of theſe ſubſtances contains water, and both a
ſuppoſed, in the new theory, to be ſimple bodie
the experiment might, perhaps, afford an intereſti
reſult.

Phoſphorus and iron.

If equal parts of phoſphoric glaſs, and iron cli
pings, together with one-ſixteenth of a part of pulv
rized charcoal, be fuſed together, the mixture is ve
brittle, white in its fracture, and of a ſtriated a
granulated texture. This combination of iron w
ph

Cold ſhort iron.

Siderite.

oſphoric acid is found in the iron produced from
g ores, which abound in the remains of decayed
etables. It is the cauſe of brittleneſs in the iron
en cold; which occaſions that kind of iron to be
led cold ſhort iron by the workmen. Phoſphorated
n was at firſt taken to be a peculiar metal; and
s called ſiderite by Bergman.

Metallic combinations.

Tinning of iron plates.

Iron unites with gold, ſilver, and platina. When
ited to a white heat, and plunged in mercury, it
comes covered with a coating of that metal. Long
uration of mercurial amalgams likewiſe cauſes a
iting to adhere to the ends of iron peſtles; and
all ſteel ſprings, kept plunged beneath the ſurface
mercury in certain barometers, have become brittle
proceſs of time: hence there appears to be a
ak action between mercury and iron. Iron and
very readily unite together; as is ſeen in the art
tinning iron veſſels, and in the fabrication of thoſe
ful plates of iron, coated with tin, which are gene-
ly diſtinguiſhed by the ſimple name of tin alone. The
ef art of applying theſe coatings of tin conſiſts in
ending the metals from calcination by the acceſs of
. After the iron plates are ſcraped, or rendered very
an by ſcouring with an acid, they are wetted with a
ution of ſal ammoniac, and plunged into a veſſel
ntaining melted tin; the ſurface of which is co-
ed with pitch or tallow, to preſerve it from calci-
tion. The tin adheres to and intimately combines
th the iron to a certain depth, which renders the
ned plates leſs diſpoſed to harden by hammering,
n before, as well as much leſs diſpoſed to alter, by
united action of air and moiſture. The proceſs
for

IRON.

Combinations of iron with metallic ſubſtances.

for tinning of iron veſſels does not eſſentially diffe from that which has already been deſcribed of copper veſſels. Iron does not unite with biſmuth, at leaſt i the direct way. As nickel cannot be purified from iron without the greateſt difficulty, it may be preſumed that theſe ſubſtances would readily unite, if the ex treme infuſibility of both did not preſent an obſtacl to the chemical operator. Arſenic forms a brittle ſub ſtance in its combination with iron. This ſemi-metal which is ſo abundant in the mineral kingdom, is ſai to be the cauſe of the brittleneſs which ſome ſpe cimens of iron poſſeſs when hot, though malleabl when cold. Iron, thus contaminated, is diſtinguiſhe by workmen by the name of red ſhort iron. Coba forms a hard mixture with iron, which is not eaſi broken. The inflammability and volatility of zi preſent an obſtacle to its combination with iron. is not improbable, however, but that clean iron filin would unite with zinc, if that metal were kept contact with them for a certain time, in a heat n ſufficient to cauſe it to riſe; for it has been foun that zinc may be uſed in the operation of coati iron in the ſame manner as tin. Antimony unit with iron, and forms a hard brittle combinatio which yields, in a ſlight degree, to the hammer. T combination of ſulphur, and the regulus of antimon which is commonly known by the name of antimon is decompoſed by virtue of the greater affinity of t iron to the ſulphur. For this purpoſe, five ounces the points of nails from the farriers may be made r hot in a crucible; one pound of pulverized ore of an mony muſt then be thrown into the crucible, a

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Combinations of iron with metallic ſubſtances.

heat quickly raiſed to fuſe the whole. When the on is perfect, an ounce of nitre in powder may be wn in, to facilitate the ſeparation of the ſcoriæ. er the maſs is cooled, the antimony is found ſepa- at the bottom of the crucible, while the iron re- ins in combination with the ſulphur and alkali. If proportion of the iron be conſiderably greater n five ounces to the pound of antimonial mineral, regulus will be alloyed with iron. Mangeneſe is oſt always united with iron in the native ſtate. olfram forms a brittle whitiſh-brown hard alloy, of ompact texture, when fuſed with white crude iron. The habitudes of iron with the regulus of molyb- a are not known.

Native iron and its ores.

ron is the moſt diffuſed, and moſt abundant, of tallic ſubſtances. Few mineral bodies, or ſtones, without an admixture of this metal. Sands, clays, l the waters of rivers, ſprings, rain, or ſnow, are rcely ever perfectly free from it. The parts of mal and vegetable ſubſtances likewiſe afford iron in reſidues they leave after incineration. It has been nd native, in large maſſes, in Siberia *, and in the ernal parts of South America. This metal how- r in its native ſtate is ſcarce: moſt iron is found the calciform ſtate, in ochres, bog ores, and other able earthy ſubſtances, of a red, brown, yellow, or ck colour. The hæmatites, or blood ſtones, are ewiſe calciform ores of iron: theſe are either of red colour, or blue, yellow, or brown. This uſeful

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* See Bergman's Eſſays; Magellan's improved edition of onſtedt's Mineralogy; and the Philoſ. Tranſ. lxxviii. 37.

metal

Ores of iron.

metal is ſo abundant, that whole mountains are com-
poſed of iron ſtone; whereas, other metals uſually
run in ſmall veins. Beſides the calciform ores o
iron, which are either nearly pure, or elſe mixed
with earths, as in ſpars, jaſper, boles, baſaltes, &c
iron is mineralized with ſulphur, as in the pyrites
with arſenic, in the white pyrites; or with both. A
iron ore is likewiſe found, of a blue colour, an
powdery appearance, which is thought to be of th
ſame nature as Pruſſian blue. The coaly iron ore
contain bitumen. The magnet, or loadſtone, is a
iron ore, whoſe conſtitution has not yet been accu
rately examined. Iron is alſo found in combinatio
with the vitriolic acid, either diſſolved in water, or i
the form of vitriol.

Humid analyſis of iron ores.

To analyſe the ores of iron in the humid way, th
muſt be reduced to a very ſubtle powder, and repea
edly boiled in marine acid. If the ſulphureous or
ſhould prove ſlow of ſolution, a ſmall quantity
nitrous acid muſt be added to accelerate the operatio
The iron being thus extracted, the inſoluble part
the matrix only will remain. Pruſſian alkali, bein
added to the decanted ſolution, will precipitate t
iron in the form of Pruſſian blue. This precipitat
when waſhed and dried, will be equal in weight
ſix times the quantity of metallic iron it contain
and from this iron four parts in the hundred muſt
deducted, to allow for the iron which is contain
in the Pruſſian alkali itſelf. But as this alkali, a
every other preparation containing the Pruſſian ac
does not conſtantly afford the ſame quantity of ir
the moſt exact way, in the uſe of ſuch preparatio

Page 302.

conſi

iſts in previouſly diſſolving a known quantity of
n in vitriolic acid; and precipitating the whole by
addition of the Pruſſian alkali. This reſult will
rd a rule for the uſe of the ſame alkali in other
ations. For as the weight of the precipitate ob-
ned in the trial experiment, is to the quantity of
n which was diſſolved and precipitated; ſo is the
ight of the precipitate obtained from any other
ation, to the quantity of iron ſought.

If the iron be united to any conſiderable proportion
zinc or manganeſe, the Pruſſian blue muſt be cal-
ned to redneſs, and treated with pale nitrous acid,
ich will take up the calx of zinc. The manganeſe
y then be diſſolved by nitrous acid, with the addi-
n of ſugar; and the remaining iron being diſſolved
marine acid, and precipitated by mild mineral
ali, will afford 225 grains of precipitate for every
0 grains of metallic iron.

Analyſis in the dry way.

To examine the ores of iron in the dry way, the
ly requiſite is fuſion, in contact with charcoal.
r this purpoſe, eight parts of pulverized glaſs, one
calcined borax, and half a part of charcoal, are to
well mixed together. Two or three parts of this
x, being mixed with one of the pounded ore, and
ced in a crucible, lined with a mixture of a little
y and pounded charcoal, with a cover luted on, is
be urged with the ſtrong heat of a ſmith's forge for
lf an hour. The weight of the ore, in this experi-
ent, ſhould not exceed 60 grains. Other proceſſes
r determining the contents, or metallic product, of
on ores, are inſtituted by performing the ſame ope-

IRON.

rations in the ſmall, as are intended to be uſed in the large way.

Smelting of iron in the large way.

In the large iron works, it is uſual to roaſt, or calcine the ores of iron, previous to their fuſion; as well for the purpoſe of expelling ſulphureous or arſenical parts, as to render them more eaſily broken into fragments of a convenient ſize for melting. The mineral is melted, or run down, in large furnaces from 16 to 30 feet high; and variouſly ſhaped, either conical or elliptical, according to the opinion of the iron maſter. Near the bottom of the furnace is an aperture for the inſertion of the pipe of large bellows worked by water or ſteam, or of other machines fo producing a current of air; and there are alſo holes a proper parts of the edifice, to be occaſionally opened to permit the ſcoriæ and the metal to flow out, as th proceſs may require. Charcoal, or coke, with lighte bruſhwood, is firſt thrown in; and when the whol inſide of the furnace has acquired a ſtrong ignitio the ore is thrown in by ſmall quantities at a tim with more of the fuel, and commonly a portion o limeſtone, as a flux: the ore gradually ſubſides int the hotteſt part of the furnace, where it becom fuſed; the earthy part being converted into a kin of glaſs; while the metallic part is reduced by th coal, and falls through the vitreous matter to th loweſt place. The quantity of fuel, the additions, an the heat, muſt be regulated, in order to obtain iron any deſired quality; and this quality muſt likewiſ in the firſt product, be neceſſarily different, accordin to the nature of the parts which compoſe the ore.

Th

States of iron.

The three kinds of crude iron.

The iron which is obtained from the fmelting fur-
ces is not pure; and may be diftinguifhed into
ee ftates:—white crude iron, which is brilliant
its fracture, and exhibits a cryftallized texture,
ore brittle than the other kinds, not at all mallea-
, and fo hard as perfectly to withftand the file:
ey crude iron, which exhibits a granulated and dull
xture when broken; this fubftance is not fo hard
d brittle as the former, and is ufed in the fabrica-
on of artillery, and other articles which require to
bored, turned, or repaired: and black caft iron,
hich is ftill rougher in its fracture; its parts adhere
gether lefs perfectly than thofe of the grey crude
on: this is ufually fufed again with the white crude
on.

Refining of iron.

Whenever crude iron, efpecially the grey fort, is
ufed again with contact of air, it emits fparkles, lofes
eight, and becomes lefs brittle. In order to convert
into malleable iron, it is placed on a hearth, in the
idft of charcoal, urged by the wind of two pair of
ellows. As foon as it becomes fufed, a workman con-
nually ftirs it with a long iron inftrument. During
e courfe of feveral hours it becomes gradually lefs
ufible, and affumes the confiftence of pafte. In this
ate it is carried to a large hammer, the repeated
lows of which drive out all the parts that ftill
artake of the nature of crude iron fo much as to
etain the fluid ftate. By repeated heating and ham-
mering more of the fufible iron is forced out; and
the remainder, being malleable, is formed into a bar,
or other form, for fale. Crude iron lofes upwards of
one-fourth of its weight in the procefs of refining.

Purified,

IRON.

Bar iron.

Purified, or bar iron, is ſoft, ductile, flexible, malleable, and poſſeſſes all the qualities which have been enumerated in this chapter, as belonging excluſively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition deſtroys this fibrous texture, and renders the iron more uniform throughout; but hammering reſtores it.

Iron converted into ſteel by cementation.

Hardening.

Tempering.

If the pureſt malleable iron be bedded in pounded charcoal, in a covered crucible and kept for a certain number of hours in a ſtrong red heat (which time muſt be longer or ſhorter, according to the greater or leſs thickneſs of the bars of iron), it is found that by this operation, which is called cementation, the iron has gained a ſmall addition of weight, amounting to about the hundred and fiftieth, or the two hundredth part; and is remarkably changed in its properties. It is much more brittle and fuſible than before. Its ſurface is commonly bliſtered when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous ſtate. This cemented iron is called ſteel. It may be welded like bar iron; but its moſt uſeful and advantageous property is that of becoming extremely hard when ignited, and plunged in cold water. The hardneſs produced is greater in proportion as the ſteel is hotter and the water colder. The colours which appear on the ſurface of ſteel ſlowly heated, are yellowiſh white, yellow, gold colour, purple, violet, deep blue, yellowiſh white; after which the ignition takes place. Theſe ſigns direct the artiſt in tempering, reducing

th

hardneſs of ſteel to any determinate ſtandard. If
i be too hard, it will not be proper for tools which
intended to have a fine edge, becauſe it will be
rittle that the edge will ſoon become notched; if
e too ſoft, it is evident that the edge will bend or
. Some artiſts ignite their tools, and plunge
n in cold water; after which, they brighten the
ace of the ſteel upon a ſtone: the tool being then
upon charcoal, or upon the ſurface of melted lead,
laced in the flame of a candle, gradually acquires
deſired colour; at which inſtant they plunge it
water. Others, eſpecially in larger inſtruments,
ge the tool into very cold water as ſoon as it is
pletely ignited; and, when it ceaſes to be lumi-
; beneath the water, they take it out, rub it
kly with a file, or on a plate covered with ſand,
it may acquire a white ſurface. The heat which
metal ſtill poſſeſſes ſoon begins to produce the
eſſion of colours. If a hard temper be deſired, the
is dipped again, and ſtirred about in the cold
r as ſoon as the yellow tinge appears. If the
le appear before the dipping, the temper will be
or gravers, and tools uſed in working upon me-
if dipped while blue, it will be proper for
gs, and for inſtruments uſed in the cutting of
ſubſtances, ſuch as cork, leather, and the like;
f the laſt pale colour be waited for, the hardneſs
e ſteel will ſcarcely exceed that of iron. It is
rcumſtance worthy of remark, that ſteel has a
ſpecific gravity when hardened than when ſoft;
here are no circumſtances, upon which a proba-
onnection between theſe two properties, namely

The proceſſes for hardening and tempering of ſteel.

the increaſed hardneſs, and the diminiſhed ſpecific
gravity, can be made out.

The uſual time required for the cementation o
ſteel, is from ſix to ten hours. If the cementation b
continued too long, the ſteel becomes porous, brittl
of a darker fracture, more fuſible, and incapable o
being forged or welded. On the contrary, ſteel ce
mented with earthy infuſible powders, is graduall
reduced to the ſtate of forged iron again. Simp
ignition produces the ſame effect; but is attend
with calcination of the ſurface. The texture of ſteel
rendered more uniform by fuſing it before it is ma
into bars: this is called caſt ſteel; and is rather mo
difficultly wrought than common ſteel, becauſe it
more fuſible, and is diſperſed under the hammer
heated to a white heat.

Caſt ſteel.

Compariſon of ſteel and crude iron.

When we conſider the operations by which cru
iron is brought into the malleable ſtate, then c
verted into ſteel, and afterwards into a fuſible m
tal, which is not malleable; we may perceive t
ſteel-making is a kind of inverſion of the proceſ
refining iron, as practiſed in the firſt inſtance. W
the calx of iron is mixed together in the ſmelt
furnace, with combuſtible matter and glaſs, it
either be completely or partially revived, accord
to the management of the proceſs. Much of the
will however be ſo enveloped with the vitreous m
ter, as to remain unburned: and the reduced i
with which it may be in contact, will be in the ſ
ſituation as forged iron in the cementing pot; th
to ſay, it will be in contact with coal at a very
vated temperature, and defended from the air. F

he great infuſibility of iron, it may reaſonably be oncluded that the reduced metal does not flow into he bottom of the furnace, until the charcoal has con- erted it into a fuſible matter ſimilar to ſteel, by the ame action which takes place in cementation, what- ver that action may be. Hence it muſt follow, that e various ſpecimens of crude or caſt iron will differ their qualities, as well on account of the degree of mentation they have undergone, as the degree of duction which has taken place among the metallic arts, which are carried down, and form the whole aſs. Since the coal, in the proceſs of cementation, mmunicates or adds weight to the iron; and ſince ude iron, as well as ſteel, exhibits ſparkles, and is ore eaſily burned than other iron: it may therefore concluded that, in the proceſs of refining, that part the inflammable ſubſtance which had united with e metal is burned, and leaves the iron much leſs ſible than before. Stirring the maſs multiplies the ntacts of the air with the burned ſubſtances; theſe rfaces of contact will therefore ſucceſſively afford in coats of infuſible metal. In this manner it is und, that if a large piece of crude iron be expoſed heat in a wind furnace, the external part will be prived of its fuſibility during the time required to oduce a ſtrong heat in the whole maſs; and the in- rnal part will be melted, and run out, leaving the ell behind. Iron which is of the conſiſtence of paſte ay therefore be conſidered, like any other paſte, as a ixture of a fluid with a ſolid. It will be eaſily un- rſtood that the forging will bring the parts of diffi- lt fuſion together, and extrude the leſs refined and

Page 318.

Conſideration of the effects of heat in refining iron.

fluid parts: it will alſo be evident that this operation is not likely to drive out the whole of the fuſible matter. When the iron has arrived at that ſtate wherein the quantity of fibre or tough iron is ſufficient to anſwer the mechanical purpoſes to which it is intended to be applied, the artiſt will conſider it as ſufficiently refined; and the reſidue of fuſible iron contained in the bar anſwers, in all probability, the valuable purpoſe of connecting theſe infuſible maſſes together. Thus we find that forged iron appears as if covered with a varniſh, when urged to a white heat; we find that this varniſh is more abundant in ſteel; and tha iron and ſteel may be reſpectively welded together b application in this ſtate; an effect which it would b very difficult to account for, in this moſt infuſible o metals, if it were not for ſuch an admixture. Bu caſt ſteel, ſteel over-cemented, and crude iron, appea to be in the ſtate of all other metals, platina excepte They cannot be welded, becauſe welding implies a pa tial fuſion; or an effect ſimilar to the gluing or uni ing of ſolids by the application of a fluid, which afte wards becomes conſiſtent. And if it be true that pl tina poſſeſſes this valuable property, it ſeems reaſo able to infer that it muſt alſo conſiſt of two metall ſubſtances of different degrees of fuſibility.

Probable cauſe of the property of welding.

Platina.

Crude iron and ſteel.

Crude iron, and ſteel of an uniform texture, conſ therefore of a fuſible combination of iron with t combuſtible ſubſtance of the coal, or ſomething whi is imparted from it; the crude iron differing fr the ſteel ſimply in being over-cemented, and l pure, on account of the admixture of metallic ca which can ſcarcely, perhaps, be avoided in the lar

procc

roceſs. It appears therefore that crude iron muſt ſs through the ſtate of ſteel before it can become rged iron; and conſequently that the fabrication ſteel from this laſt is a circuitous proceſs, which n only be repaid by the abſence of thoſe unreduced rts which may exiſt in the crude iron. At ſome rges, however, where the ore, the flux, the fuel, and e management, are adapted to each other, the proce affords ſteel, when duly refined. At other maıfactories, the crude iron is either refined, or conrted into ſteel, by running it into thin plates, which e ſtratified with charcoal, and burned in a cloſe furce. In this way, the metal is refined by degrees, ithout undergoing fuſion; and if the heat be raiſed that of cementation, the iron will not only be duced, but converted into ſteel. In the forges of rinthia the grey crude iron is alſo converted either to ſoft iron, or ſteel, according to the management a ſomewhat ſimilar proceſs. The iron is fuſed in rge melting pot; and a ſmall quantity of water beg thrown upon the ſurface of the metal, cauſes a thin te to congeal, which is taken off; and, by continuing operation, the greateſt part of the fuſed iron bemes converted into plates. To produce ſteel, theſe tes are again fuſed, and kept a long time in an vated heat; at the ſame time that the metal is fended from the contact of the air by a ſufficient antity of the vitreous ſlag. To produce ſoft iron, e plates are expoſed to a continued roaſting, while e air is conſtantly renewed by means of two pair of llows. The extenſive ſurface of the plates renders

Proceſſes for refining crude iron, and making ſteel in a direct way.

it unneceſſary to uſe that agitation, or ſtirring, which is required when fuſed crude iron is refined. In theſe proceſſes it is evident that the ſame matter in the crude iron, which it obtained in the ſmelting furnace, is employed, and ſupplies the place of the charcoal of cementation in forming the ſteel; and, on the other hand, that this ſubſtance, which prevented the crude iron from being ſoft, tough, and infuſible, is burned away, together with a portion of the iron itſelf, while the remainder is left in a much purer ſtate.

The exiſtence of plumbago in crude iron and ſteel; aſcertained in the dry way.

Theſe are the facts obſerved at the furnaces. But the obſervations and inquiries of the chemiſt muſt be carried farther, in order to determine what it is that iron gains or loſes at the time of its converſion into its various ſtates. It is found that crude iron approaches towards the ſoft ſtate, not only by heating with expoſure to air, which burns the combuſtible addition, but likewiſe by fuſion, without the free acceſs of air. In this caſe, when the fuſion has been complete, and the cooling gradual, it is found that a black ſubſtance is thrown up to its ſurface, which is more abundant the greyer or blacker the iron; and the ſam black ſubſtance is obſerved to coat the ladles of forge iron, which are uſed to take out the metal, and pour i into moulds for caſting ſhot, and other articles. I appears therefore that the heated iron, like othe heated fluids, is capable of holding a larger quantit of matter in ſolution than when cold; and that portion of this black ſubſtance ſeparates during th cooling, whether by the gradual effect of ſurroundin bodies or by the contact of the ladle, in the ſam

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ıanner as various ſalts are ſeparated, in part, from ater by a diminution of temperature. From cheıical analyſis, as well as from its obvious characters, ıis black ſubſtance is found to be plumbago, or the ıaterial uſed to make pencils, and commonly known y the name of black lead.

Plumbago extricated from iron in the humid way.

The preſence of this black matter is likewiſe exhited by diſſolving ſteel, or crude iron, in acids, in hich plumbago is inſoluble, and therefore remains ehind in the form of a powder. Hence likewiſe is educed the cauſe of the black ſpot which remains pon ſteel, or crude iron, after its ſurface has been ɔrroded by acids; for this ſpot conſiſts of the plumıgo which remains after the iron has diſappeared by ılution.

Quantities of plumbago, and of inflammable air, afforded by various kinds of iron.

Solution in the vitriolic or marine acids, not only ıhibits the plumbago contained in iron, but likewiſe ɔſſeſſes the advantage of ſhewing the ſtate of its duction by the quantity of inflammable air which is ſengaged: for whether this aërial fluid be ſupplied y the phlogiſton of the iron, or from the decomɔſed water, it is agreed on all hands that its quanty, in like circumſtances, is proportional to that of ıe iron which is converted into calx. There are conderable differences between the various products of ıe ſmelting furnace in theſe reſpects; but it is found ıat the white crude iron affords the leaſt quantity of ıflammable air in proportion to its bulk, and leaves moderate portion of plumbago; the grey crude ɔn affords more inflammable air, and more plumıgo, than the white; and the ſofteſt bar iron affords ıoſt inflammable air of any, and little or no plumbago. The quantities of inflammable air[*], at a medium, by ounce meaſures, were 62, afforded by 100 grains of the white crude iron; 71 by the grey crude iron; and 77 by the malleable iron.

Degrees of reduction and cementation in iron.

Hence it may be inferred that, in the white crude iron, the proceſſes of reduction and cementation are both carried to a leſs extent than in the grey crude iron, which is produced by means of a ſtronger heat, excited with a larger quantity of fuel: and that the reduction of grey crude iron is ſtill leſs perfect than that of the ſoft bar iron; though this laſt, by the refining in an open veſſel, is ſo far from being more cemented, that it ſcarcely contains any plumbago at all.

Inaccuracies.

It muſt be admitted, however, that the ſolution in acids ſerves only to ſupport theſe general concluſions, in conjunction with the facts obſerved in the dry proceſſes; but cannot accurately ſhew either the quantities of inflammable air or plumbago afforded by the ſeveral kinds of iron. For the plumbago, as it becomes diſengaged, floats on the top of the vitriolic acid; where it gradually diſappears, though inſoluble in that acid. It muſt therefore be taken up by the inflammable air; and it is found that the volume of this air is diminiſhed by the abſorption. Hence there is a double ſource of inaccuracy from the loſs of plumbago, and the contraction of the inflammable air.

Plumbago.

As plumbago appears to be a compound of iron and combuſtible matter, and as the properties and

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[*] Acad. Par. 1786, pages 166, 167. The numbers in the text are given as a rough meaſure; for, in fact, there can be no medium.

effect

ffects of iron, in its various ſtates, cannot be well nderſtood without a reference to thoſe of this ſubance, it will be expedient to give an account of it in is place, inſtead of referring it to the next ſection.

Characters of plumbago.

Plumbago, or black lead, is a well-known ſubnce, of a black colour, and ſhining appearance, hen cut. Its texture is rather ſcaly; but its fracre exhibits a granular and dull appearance. None the ſpecimens have any conſiderable hardneſs. This ineral is found in England, Germany, France, ain, and Africa; but the ſort beſt adapted for aking pencils comes chiefly from Borrowdale in imberland. For this purpoſe, it is carefully ſawed o narrow ſlips, or pieces, not more than one-tenth an inch thick; which are glued between two half inders of cedar wood. An inferior kind of pencils made by the Jews, by mixing the powder or ſawſt with gum arabic, or fuſing it with reſin or phur; and preſſing or pouring it into the cavities reeds. The powder of plumbago, with three times weight of clay, and ſome hair, makes an excellent ting for retorts; and the black lead or Heſſian cibles are compoſed of the ſame materials.

Habitudes.

lumbago is not ſubject to alteration by expoſure to action of air or water; and it is inſoluble in acids. cloſed veſſels it is either entirely, or nearly, unalble by the ſtrong heat of a furnace; but by conued ignition, and occaſional ſtirring in a ſhallow ſel, under a muffle, it is gradually diſſipated, or ned, leaving a reſidue of calx of iron, of about -tenth of the original weight. It detonates with e in a red heat; ten parts of this ſalt are required

Experiments tending to diſcover the component parts of plumbago.

quired to one of plumbago before the whole will be decompoſed, and exhibit no reſidue of plumbago when the alkali is diſſolved in water. The aërial product of this detonation is found to conſiſt of a mixture of one-third fixed air; and the reſt air which maintains combuſtion: the alkali contains fixed air; and ſome of the nitre is driven up by the heat. In order to ſhew that the fixed air came from the plumbago, and not from the nitre, the firſt analyſer* of this ſubſtance detonated tin, antimony, and ſulphur, reſpectively, with nitre, and obtained no fixed air: and, ſtill more to place the inference beyond a doubt, he expoſed plumbago to diſtillation, with twice its weight of dry acid of arſenic: the acid was reduced to the ſtate of white calx and ſublimed; and pure fixed air came over. Similar reſults were had with the calces of mercury and lead; the metals were revived, and fixed air was expelled. When pulverized plumbago was diſtilled with cauſtic fixed alkali by ſtrong heat, the volatile product was inflammable air and the remaining alkali contained fixed air.

Phlogiſtic theory.

From theſe, and other facts, he concluded, th plumbago is a compound of phlogiſton and fixed ai with a little iron, which he ſuppoſed to be accidenta The exiſtence of the phlogiſton was judged to b proved by its detonation with nitre, as well as by th revival of the acid of arſenic and the metallic calce and the extrication of inflammable air by alkali: h inferred the quantity of phlogiſton in this ſubſtan to be twice as much as in charcoal; becauſe it r

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* Scheele. See his Eſſays, Eng. Tranſ. Eſſay XIII.

IRON.

s twice the quantity of nitre for its detonation.
preſence of fixed air was deduced from the aërial
ucts in all the diſtillations but the laſt; and from
nild ſtate of the alkalis, in thoſe trials wherein
were uſed.

Antiphlogiſtic theory of plumbago.

ie antiphlogiſtic philoſophers * conſider plumbago
compound of iron, and the acidifiable baſe of
air, which they call carbone, becauſe it exiſts
abundantly in charcoal. The difficulty of burn-
r decompoſing it, is conſidered as a conſequence
e combination of its parts, which are leſs diſpoſed
ite with vital air, than either would be if alone.
ſame difficulty accounts for the large proportion
itre required to deflagrate with it completely;
ntity required, not becauſe there is much com-
ble matter to be burned, but becauſe a long
nued and elevated heat is neceſſary; by which
is much of the nitre is decompoſed, and its vital
lies off, without having been employed in the
uſtion, as appears by the two thirds of the elaſtic
uct, which will ſupport the flame of a candle.
other facts are eaſily adapted to this theory. By
ation with nitre it affords fixed air, becauſe the
uſtible baſe is acidified by the vital air of the
. The arſenical acid, and metallic calces, are
ced by the abſtraction of the vital air they con-
d; which vital air, combining with the acidifi-
baſe contained in the plumbago, converts it into
fixed air, or acid, which flies off: And, laſtly, in
diſtillation of plumbago with humid alkali, a de-

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* Acad. Par. 1785, pag. 132, et ſeq.

compo-

compoſition of the water takes place: its inflamm ble air flying off; and its vital air, combining wi the acidifiable baſe, as before, forms fixed air, whi unites with the alkali, and renders it mild.

Reſemblance between plumbago and pyrites.

The chief difference in the matter of fact betwe theſe theoriſts appears to conſiſt in the iron; whi the latter conſider as a neceſſary part of the combin tion; by means of which they account for its difficu combuſtibility. Since plumbago does really conta iron, it may be conſidered as a compound of a ſimil nature to the martial pyrites. Thus in the pyrites ir is united to ſulphur; which the phlogiſtian philo phers aſſert to be a compound of vitriolic acid (or baſe) and phlogiſton, while their opponents take t ſulphur to be a ſimple ſubſtance, capable of acidifi tion by the addition of vital air: and ſo likewiſe plu bago is a compound of iron, united to another ſu ſtance; which the phlogiſtians aſſert to be fixed a combined with phlogiſton; at the ſame time th the other party, rejecting the inflammable princip affirm that it is the ſimple acidifiable baſe, which w form fixed air when vital air is added to it. ſee therefore that it is the explanation, and not facts, which forms the object of contention.

Page 417. 149.

Recapitulation of the facts relating to the ſtates of iron.

Since crude iron, then, contains the baſe of fi air in combination, of which it may be depriv by heat with acceſs of vital air, which convert into the acid ſtate; and ſince it again recovers t baſe by cementation with charcoal, there can be doubt but the plumbago is afforded by the fuel being highly probable that iron is neceſſary to its parate exiſtence. It appears alſo that the reduction

netallic calx takes place firſt at a lower tempera-
and that the combination of the baſe of fixed
llows at a greater heat. Whence, in the refining
on, the plumbago is firſt burned, and the iron re-
s reduced; and, in the cementation of bar iron,
ıetal is converted into ſteel, with bliſters on its
:e; which moſt probably ariſe from fixed air
:d by the vital air of ſome portions of unreduced
uniting with the acidifiable baſe from the char-
And, laſtly, as iron holds this acidifiable baſe,
ılogiſticated acid, in ſolution, ſo likewiſe it may
ɔe ſeparable from this metallic ſolvent, without
ing a portion with it; in the ſame manner as ſalts,
h cryſtallize in water, always take up part of the
ıt in the formation of their cryſtals.

Refining.

Cementation.

Uſes of iron.

would require many volumes to enumerate the
ıg uſes of iron. This moſt valuable of metals is
:d to ſo many, and ſuch important uſes, that we
ɔt look round us without ſeeing its effects. When
ɔntemplate the innumerable effects of human in-
y, and aſk ourſelves the ſimple queſtion, could
ave been done without iron? there is not a ſingle
ıce which will not immediately ſhew its value.
indeed difficult to form an idea, how civilized
:y could exiſt without it.

CHAP.

CHAP. VIII.

CONCERNING TIN.

TIN.

Characters of tin.

TIN is a metal of a yellowiſh-white colour, co ſiderably harder than lead, ſcarcely at all ſo rous, very malleable, though not very tenacious. Wir cannot be made of it; but, under the hammer, it extended into leaves, called tin foil, which are abo one-thouſandth of an inch thick; and might eaſ be beaten to leſs than half that thickneſs, if the p poſes of trade required it. The proceſs for maki tin foil conſiſts ſimply in hammering out a num of plates of this metal, laid together upon a ſmo block, or plate of iron. The ſmalleſt ſheets are thinneſt. Its ſpecific gravity is leſs than that of a other malleable metal. Long before ignition, it m at about the 410th degree of Fahrenheit's therm meter; and, by a continuance of the heat, it is ſlo converted into a white powder by calcination. L lead, it is brittle when heated almoſt to fuſion; exhibits a grained or fibrous texture, if broken the blow of a hammer; it may alſo be granulated agitation at the time of its tranſition from the flui the ſolid ſtate. The calx of tin reſiſts fuſion m ſtrongly than that of any other metal; from wh property, it is uſeful to form an opake white enam when mixed with pure glaſs in fuſion. The brig neſs of its ſurface, when ſcraped, ſoon goes off

expoſ

ſure to the air; but it is not ſubject to ruſt, or
oſion, by expoſure to the weather.

Solution of tin in vitriolic acid:

oncentrated vitriolic acid, aſſiſted by heat, diſſolves
its weight of tin, at the ſame time that vitriolic
air eſcapes in great plenty. By the addition of
er a calx of tin is precipitated. Vitriolic acid,
tly diluted, likewiſe acts upon this metal; but if
h water be preſent, the ſolution does not take
e. In the vitriolic ſolution of tin there is an
al formation, or extrication of ſulphur, which
ders the fluid of a brown colour whilſt it conti-
s heated, but ſubſides by cooling. The tin is
wiſe precipitated in the form of a white calx by
ntinuance of the heat, or by long ſtanding with-
heat. This ſolution affords needle-formed cryſtals
ooling.

— in nitrous acid.

itrous acid and tin combine together very rapidly,
hout the aſſiſtance of heat. Moſt of the metal
down in the form of a white calx, extremely diffi-
of reduction; and the ſmall portion of tin which
ains ſuſpended, does not afford cryſtals, but falls
n, for the moſt part, upon the application of heat,
nſpiſſate the fluid. The ſtrong action of the ni-
s acid upon tin produces a ſingular phenomenon,
ich is happily accounted for by the modern diſco-
ies in chemiſtry. Mr. De Morveau * has obſerved
t, in a ſolution of tin by the nitrous acid, no elaſtic
d was diſengaged; but that volatile alkali was
med. This alkali muſt have been produced by
phlogiſticated air of that part of the nitrous acid

Singular effect.

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* Kirwan on Phlogiſton, 2d edition, p. 234.

which

Volatile alkali produced from nitrous acid, &c.

which was employed in affording pure air to calcine the tin. The phlogiſticated air muſt therefore hav combined with inflammable air: but whether this inflammable air was afforded by a decompoſition of th water of the menſtruum, or whether it came from the phlogiſton of the tin, is a queſtion that mu remain undetermined, until deciſive experiments hav been made for the eſtabliſhment of one or the othe of the two theories, which at preſent divide the chemical world.

Solution of tin in marine acid:

The marine acid diſſolves tin very readily, at th ſame time that it becomes of a darker colour, an ceaſes to emit fumes. A ſlight efferveſcence tak place with the diſengagement of a fetid inflammab gas. Marine acid ſuſpends half its weight of tin, an does not let it fall by repoſe. It affords permane cryſtals by evaporation. If the tin contain arſeni it remains undiſſolved at the bottom of the fluid.

— in dephlogiſticated marine acid:

Dephlogiſticated marine acid diſſolves tin very re dily, and without ſenſible efferveſcence. The ſoluti itſelf does not appear to differ from the foregoing.

—in aqua regia.

Aqua regia, conſiſting of two parts nitrous a one marine acid, combines with tin with efferveſcen and the developement of much heat. In order obtain a permanent ſolution of tin in this acid, is neceſſary to add the metal by ſmall portions at time; ſo that the one portion may be entirely diſſolv before the next piece is added. Aqua regia, in th manner, diſſolves half its weight of tin. The ſo tion is of a reddiſh brown, and in many inſtan aſſumes the form of a concrete gelatinous ſubſtan The addition of water ſometimes produces the c

cr

TIN.

Solution of tin in aqua regia.

form in this ſolution, which is then of an opal
ur, on account of the calx of tin diffuſed through
ubſtance. The uncertainty attending theſe expe-
nts, with the ſolution of tin in aqua regia, ſeems
epend upon the want of a ſufficient degree of
racy in aſcertaining the ſpecific gravities of the
acids which are mixed; the quantities of each,
of the tin, together with that of the water added.
probable that the ſpontaneous aſſumption of the
rete ſtate depends upon water imbibed from the
ſphere. The ſolution of tin in aqua regia is uſed
yers to heighten the colours of cochineal, gum
nd ſome other red tinctures, from crimſon to a
t ſcarlet, in the dying of woollens.

Acid of tin.

Hermſtædt has ſucceeded in the actual acidifi-
n of this metal, by treating it with the marine
itrous acids. He diſſolves pure tin in pure ma-
acid, and boils this ſolution with nitrous acid
led from manganeſe) until the red vapours ceaſe
pear. The fluid, which is then limpid, is ex-
to diſtillation until the whole of the marine
itrous acids have been diſſipated. The white
ning maſs is ſoluble in three parts of water, and
acid of tin. A red heat converts this matter into
w tranſparent ſubſtance, neither acid nor ſoluble
ter; but it regains both properties by a few
expoſure to the air *.

acetous acid ſcarcely acts upon tin. The ope-
of other acids upon this metal has been little
ed into.

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* Journal de Phyſ. xxxv. 391. Nov. 1789.

The fuming liquor of Libavius.

Adet's examination of the fuming liquor of Libavius.

When equal parts of an amalgam of tin and mer-
cury, and of corroſive ſublimate, are triturated toge-
ther, and the mixture expoſed to diſtillation in a retort,
by a very gentle heat; a colourleſs fluid firſt comes
over, which is followed by a thick white fume, which
becomes condenſed into a tranſparent liquor, called
the fuming liquor of Libavius, on account of the
copious fumes it emits when the veſſel that contain
it is opened. On account of the conſiderable volatili
of this liquid, it riſes, partly in the form of flowers
to the top of the bottle in which it is put; ſo that
in the courſe of ſeveral months, it becomes entirel
cloſed. The compoſition and effects of this liqui
were but imperfectly known until lately, when M
Adet made ſeveral ingenious experiments upon it. B
expoſing this liquid under receivers containing d
air, over mercury, he found that the volatile flu
aroſe, and lined the veſſel with cryſtals, when wat
was preſent; though very few cryſtals were form
when the air was as dry as it could be made. H
obſerved likewiſe, that when water was added to t
fuming liquor of Libavius, it became ſolid, and cea
to emit fumes. A preciſe quantity of water is
quired to produce this effect in the moſt perfect ma
ner. If the quantity of water be too ſmall, the liq
retains more or leſs of its diſpoſition for the fluid ſta
and if it be too conſiderable, the fluidity of the w
prevails. By ſeveral trials he found that the due p
portion of water to be added to the fuming liquor
Libavius was as 7 to 22. A kind of ebullition,
eſcape of bubbles, was produced during the comb
tion; which, on examination, was found to ariſe f

the eſcape of the air previouſly contained in the fluid water. He found likewiſe that this concrete ſubſtance, when rendered fluid by an increaſe of temperature, was capable of diſſolving more tin, without the diſengagement of inflammable air. After the concrete ſubſtance was ſaturated with tin, it could no onger be ſublimed, but might be made to undergo a red heat; during which time there was an eſcape of vapours, conſiſting of tin combined with the marine acid; and, after a ſtrong heat, the reſidue was a white calx of tin. It appeared therefore that the iquor of Libavius, rendered concrete by water, and ſaturated with tin, reſembles, in its properties, the common ſolution of tin in the marine acid.

Adet's examination of the fuming liquor of Libavius.

From theſe circumſtances, Mr. Adet concludes hat the tin, by ſtronger affinity, combines with the ërated or dephlogiſticated marine acid of the corroive ſublimate with which it is heated; that this combination contains no water; and that, as it abounds with a ſubſtance of ſuch extreme volatility as that ërated acid, its freezing point is very low, inſomuch that it is habitually fluid; that the addition of water, in a due proportion, alters the freezing point, nd renders it concrete at a common temperature; nd, laſtly, that the ſtate of the marine acid in this ubſtance is that which is called aërated, or dephloiſticated; which is proved as well from the experiments which aſcertain that ſtate in corroſive ſublimate, as from ſimilar experiments with the fuming iquor, which, as has been obſerved, is capable of diſſolving more tin without diſengaging inflammable ir. The fuming liquor of Libavius has therefore

Page 262.

the

the ſame relation to the common ſolution of tin as corroſive ſublimate has to calomel *.

The reſidue, after the diſtillation by which the fuming liquor of Libavius is produced, conſiſts of tin combined with the marine acid, calomel, and running mercury, which ſublime into the roof and neck of the retort; and at the bottom is found an amalgam of mercury and tin, covered with a ſaline combination of marine acid with tin, and ſuch other metals as the tin may have been adulterated with. Much information may be derived from the foregoing experiments of Mr. Adet reſpecting the phenomena produced when tin is diſſolved in aqua regia.

Habitudes of tin, with earths and neutral ſalts:

Earthy ſubſtances do not appear to affect this metal in the dry way. It detonates very rapidly with nitre, and becomes converted into a calx, which partly combines with the alkali. All the vitriolic ſalts are decompoſed by tin. The tin becomes calcined, and the vitriolic acid converted into ſulphur, either by the phlogiſton of the metal, according to the ancient theory; or by the ſubtraction of its vital air, according to the modern theory. This ſulphur appears to combine with the alkali, or earth of the ſalt, with which it forms an hepar that diſſolves part of the calx.

—with ſal ammoniac.

Sal ammoniac is very readily decompoſed by tin. Alkaline and inflammable air are diſengaged; and a concrete marine ſalt remains behind, which, in ſom meaſure, reſembles the fuming liquor of Libaviu The volatile alkali, or alkaline air, which eſcapes, i

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* Annales de Chimie, i. 1, &c.

diſen

lifengaged by virtue of the ſuperior affinity of the alx of tin with the marine acid, at the temperature f the experiment. The inflammable air, which likewiſe flies off, is a conſequence of the calcination of he tin; and will be derived either from the phlo-iſton of the tin, or the decompoſition of the water, ccording to the theory which may be applied in the xplanation. Notwithſtanding the facility with which iis metal decompoſes ſal ammoniac, there is an in-onvenience reſulting from its uſe, which depends on he great fuſibility of this metal; in conſequence of vhich, it cannot be intimately mixed with the ſal mmoniac, but remains at the bottom of the veſſel ı the fluid ſtate; while part of the ſal ammoniac ludes its action, and is ſublimed entire.

Spontaneous decompoſition and inflammation of metallic ſalts.

If the cryſtals of the ſaline combination of copper ith the nitrous acid be groſsly powdered, moiſtened, nd rolled up in tin-foil, the ſalt deliqueſces, nitrous umes are emitted, the maſs becomes hot, and ſudenly takes fire. In this experiment * the rapid trantion of the nitrous acid to the tin is ſuppoſed to roduce or develope heat enough to ſet fire to the itrous ſalts; but by what particular changes of capaty, has not been ſhewn.

Combination of tin with ſulphur.

If ſulphur, in powder, be added to about five times s weight of melted tin, the two ſubſtances combine, nd form a black compound, which takes fire, and is uch leſs eaſily fuſed than the tin itſelf. The maſs is rittle, and of a needled texture.

Aurum muſivum.

The combination of tin and ſulphur, called aurum

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[*] Of Dr. Higgins. Philoſ. Tranſ. lxiii. p. 137.

Aurum muſivum.

muſivum, is thus made: Melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with ſeven ounces of ſulphur, and three of ſal ammoniac. Put the powder into a matraſs, bedded rather deep in ſand, and keep it for ſeveral hours in a gentle heat; which is afterwards to be raiſed, and continued for ſeveral hours longer. If the heat has been moderate, and not continued too long, the golden-coloured ſcaly porous maſs, called aurum muſivum, will be found at the bottom of the veſſel; but, if it has been too ſtrong, the aurum muſivum fuſes to a black maſs, of a ſtriated texture. This proceſs is thus explained: As the heat increaſes, the tin, by ſtronger affinity, ſeizes, and combines with, the marine acid of the ſal ammoniac; while the alkali of that ſalt, combining with a portion of the ſulphur, flies off in the form of an hepar. The combination of tin and marine acid ſublimes, and is found adhering to the ſides of the matraſs. The mercury, which ſerved to divide the tin, combines with part of the ſulphur, and forms cinnabar, which alſo ſublimes; and the remaining ſulphur, with the remaining tin, forms the aurum muſivum, which occupies the lower part of the veſſel. It muſt be admitted, however, that this explanation does not indicate the reaſons why ſuch an indirect and complicated proceſs ſhould be required to form a ſimple combination of tin and ſulphur.

Combination of tin with phoſphorus.

When tin is heated with phoſphoric acid and charcoal, the metal appears to be very little changed. A combination, however, ſeems to take place; for the phoſphorus burns on the ſurface of the metal when heated by the blow-pipe.

Tin

Metallic mixtures.

Tin unites with biſmuth by fuſion; and becomes arder and more brittle, in proportion to the quanty of ſemi-metal added. With nickel it forms a hite brilliant maſs. It cannot eaſily be united in e direct way with arſenic, on account of the volality of this ſemi-metal; but, by heating it with the ombination of the arſenical acid and vegetable alali, the ſalt is partly decompoſed; and the tin, comining with the acid, becomes converted into a brilant brittle compound, of a plated texture. It is hought that all tin contains arſenic; and that the rackling noiſe which is heard upon bending pieces f tin is produced by this impurity. Cobalt unites ith tin by fuſion; and forms a grained mixture, of colour ſlightly inclining to violet. Zinc unites ery well with tin, increaſing its hardneſs, and dimiiſhing its ductility, in proportion as the quantity of inc is greater. This is one of the principal additions ſed in making pewter, which conſiſts, for the moſt art, of tin. The beſt pewter does not contain above ne-twentieth part of admixture, which conſiſts of zinc, copper, biſmuth, or ſuch other metallic ſubſtances as experience has ſhewn to be moſt conducive to the improvement of its hardneſs and colour. The inferior ſorts of pewter, more eſpecially thoſe uſed abroad, contain much lead, have a blueiſh colour, and are ſoft. The tin uſually met with in commerce in this country has no admixture to impair its purity, except ſuch as may accidentally elude the workmen at the mines. But the tin met with in foreign countries is ſo much debaſed by the dealers in that article, eſpecially the Dutch, that pewter and tin are conſidered

Pewter.

Miſtake of foreigners reſpecting Engliſh tin.

abroad as the ſame ſubſtance. Regulus of antimony forms a very brittle, hard, mixture with tin; the ſpecific gravity of which is leſs than would have been deduced by computation from the ſpecific gravities and quantities of each, ſeparately taken. Wolfram, fuſed with twice its weight of tin, affords a brown ſpungy calx, which is ſomewhat ductile.

Native tin.

Tin is ſcarcely ever found native. Native tin may be analyſed, in the moiſt way, by the application of nitrous acid, which calcines the tin, and diſſolves the other metals it may contain. One hundred and forty grains of the waſhed and dried calx are equivalent to one hundred grains of metallic tin. The metallic admixtures may be ſeparated from the nitrous acid by methods adapted to their reſpective properties; which may be eaſily gathered from what has already been obſerved in the humid analyſis of the metals before treated of.

Calciform ores of tin.

The calciform ores of tin are—tin ſpar, which is generally of a whitiſh or grey colour, ſometimes greeniſh or yellowiſh, ſemi-tranſparent, and cryſtallized in a pyramidical form, or irregularly—opake, brown or black tin ore, cryſtallized, and embodied in quartz, fluor, or mica, or mixed with white and yellow pyrites; theſe ores contain a mixture of iron—the reddiſh yellow, or garnet ore, which contains more of iron than of tin—and the tin ſtone, vulgarly called leadſtones, which contain ſtill leſs tin.

Tin ores containing arſenic;

and ſulphur.

It was formerly ſuppoſed that tin was frequently mineralized by arſenic; but it is now admitted that the arſenic, which may be contained in tin, is afforded by the matrix. The ſcarcity of ſulphureous tin ores

; likewiſe conſidered, till lately, as a very ſingular
, on account of the facility with which that ſub-
ce unites to tin: ſuch combinations, however,
: ſince been found. The native aurum muſivum,
n Siberia, is of this kind: and a very conſiderable
. of tin in combination with ſulphur, and an ad-
ture of copper and iron, has been found in Corn-
*. The analyſis of tin ores in the humid way
a object of ſome difficulty; becauſe they are not
d upon effectually either by the vitriolic, nitrous,
arine acids, or by aqua regia. The method of
man is as follows: The ore muſt be reduced to
ry ſubtile powder by levigation and elutriation.
laſt proceſs conſiſts in agitating any powder in
r, which is heavy enough to ſink in that fluid.
particles will be reſiſted in their deſcent, accord-
o the ſurfaces they oppoſe againſt the fluid. It is
ely neceſſary to obſerve, that a larger body pre-
a leſs ſurface to be reſiſted, than the ſame body
d oppoſe if it were divided into parts. For this
n, when a powder, conſiſting of particles of the
denſity, but different magnitudes, is agitated in
hter fluid, the largeſt pieces come firſt to the
m: and hence the method of elutriation enables
aſſort the various particles of a powder according
eir magnitudes, by firſt agitating the fluid, and
ſſively decanting it into different veſſels. Thus,
ample, if the water be decanted five ſeconds after
gitation, it will leave a powder behind it; if it

Proceſs of elutriation deſcribed and explained.

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e Magellan's Cronſtedt, p. 637. The contents of one
n were 30 parts ſulphur, 41 tin, 43 copper, 2 iron, and
matrix.

be

be again decanted, at the end of five ſeconds mor
the ſecond veſſel will contain a much finer powd
than the foregoing; and, by a third decantation, a ſt
more ſubtile powder will be obtained. This is t
Putty. method applied in the preparation of the white c
of tin, called putty, and uſed for poliſhing fine m
tallic ſpeculums, and the object lenſes of teleſcope
and in this way the tin ore to be analyſed, may
reduced to a very ſubtile powder, by levigating a
again waſhing the coarſe reſidue which ſubſides
the firſt veſſel. It may be obſerved, that the ſucceſ
decantations are unneceſſary where the very fi
Analyſis of tin ores, in the humid way: powder only is wanting; becauſe this may be as
obtained by ſuffering the water to ſtand a ſuffic
time before it is decanted off at firſt. To the
ſubtile powder of tin ore, thus afforded, a quantit
concentrated vitriolic acid muſt be added, and kep
a ſtrong digeſting heat for ſeveral hours. A ſ
portion of concentrated marine acid muſt be po
into this when cold. A ſtrong effervеſcence t
place with conſiderable heat and the eſcape of m
acid air, which has been deprived of its water b
vitriolic acid. After the expiration of an hou
two, ſome water muſt be added, and the clear l
decanted. The ſame operation muſt be repeated
the reſiduum, until the acids can diſſolve no m
and nothing will then remain but the ſtony m
The ſolution, when precipitated by means of
alkali, will afford 100 grains of metallic tin fo
132 grains of precipitate, when waſhed and
If the precipitate do not conſiſt of pure tin, bu
tain copper or iron, it muſt be calcined for a

TIN.

red heat; then digeſted in nitrous acid, which
ake up the copper; and afterwards in marine
which will diſſolve the iron.

— in the dry way.

the dry way, after pulverization, and ſeparation
ſtony matter by waſhing, the tin ores may be
fuſed with twice their weight of a mixture of
and calcined borax, in a crucible lined with
oal, and covered; or the ore may be mixed
twice its weight of tartar, one part of black
and half a part of reſin. This mixture being
ivided into three parts, each part muſt be ſuc-
ly projected into a crucible ignited to white-
which muſt be immediately covered as ſoon as
rtion thrown in ceaſes to flame.

Reduction of tin in the large way.

operation of reducing tin ores in the large
is conducted upon ſimilar principles. When
e, they are cleanſed from foreign admixtures, by
, pounding, and waſhing. A ſlight previous
ng renders the ſtony parts more friable; and,
arſenic is contained in the matrix, it is driven
a ſtrong heat, continued for a ſhort time; the
ing frequently ſtirred, to prevent its running to-
by fuſion. In the ſmelting of the ore, care is
to add a larger quantity of fuel than is uſual in
viving of other metals; and to avoid a greater
han is neceſſary to reduce the ore, in order that
ſs by calcination may be prevented as much as
le.

Countries which afford tin.

is a metal which, as far as our preſent infor-
n extends, is not very much diffuſed. It is
in Bohemia and Saxony, and on the iſland of
ca in the Eaſt-Indies. But the largeſt quanti-
ties,

ties, at leaſt for the European conſumption, are fou
in England; particularly in the county of Cornw
This iſland has been famous for its tin mines fr
the remoteſt periods of hiſtory; and would not, p
bably, have been frequented by the ancient Phœ
cian navigators, if they had not been attracted
ther by the great plenty of tin with which it abou
Several etymologiſts have endeavoured to ſhew t
the name of Britain is derived from a word comn
to the Syrian and Chaldean languages, denoting t
but on this no great ſtreſs can be laid.

Uſes.

The uſes of tin are very numerous, and ſo
known, that they ſcarcely need be pointed out. S
ral of them have already been mentioned. The
ning of iron and copper, the ſilvering of look
glaſſes, and the fabrication of a great variety of ve
and utenſils for domeſtic and other uſes, are am
the advantages derived from this metal.

C H

C H A P. IX.

CONCERNING BISMUTH.

BISMUTH.

Characters of biſmuth.

MUTH is a ſemi-metal, of a yellowiſh or ddiſh-white colour, little ſubject to change ir. It is ſomewhat harder than lead, and is y, if at all, malleable; being eaſily broken, and duced to powder by the hammer. The inter- e, or place of fracture, exhibits large ſhining diſpoſed in a variety of poſitions: thin pieces nſiderably ſonorous. At a temperature not ng the 460th degree of Fahrenheit it melts; ſurface becomes covered with a greeniſh, or brown calx. A ſtronger heat ignites it, ſes it to burn with a ſmall blue flame; at the me that a yellowiſh calx, known by the name ers of biſmuth, is driven up. This calx ap- o riſe in conſequence of the combuſtion; s very fixed, and runs into a greeniſh glaſs xpoſed to heat alone. Biſmuth, urged by a heat, in a cloſed veſſel, ſublimes entire. This tal cryſtallizes very diſtinctly, when gradually

Action of vitriolic acid.

vitriolic acid has a ſlight action upon biſmuth, is concentrated, and boiling. Vitriolic acid xhaled, and part of the biſmuth is converted hite calx. A ſmall portion combines with the acid, and affords a deliqueſcent ſalt, in the ſmall needles.

BISMUTH.

Solution in nitrous acid.

The nitrous acid attacks biſmuth with the grea
rapidity and violence; at the ſame time that m
heat is extricated, and a large quantity of nitrous
eſcapes. The ſolution, when ſaturated, affords c
tals as it cools: the ſalt detonates weakly, and le
a yellow calx behind, which effloreſces in the
Upon diſſolving this ſalt in water, it renders
fluid of a milky white, and lets fall a calx of
ſame colour.

White calx, or magiſtery of biſmuth.

The nitrous ſolution of biſmuth exhibits the
property when diluted with water; moſt of the
falling down in the form of a white calx, c
magiſtery of biſmuth. This precipitation of
nitrous ſolution, by the addition of water, i
criterion by which biſmuth is diſtinguiſhed fro
other metals. The magiſtery, or calx, is a
white and ſubtile powder, when prepared b
addition of a large quantity of water: it is uſed
paint for the complexion, and is thought gra
to impair the ſkin. The liberal uſe of any pai
the ſkin ſeems, indeed, likely to do this; but
is reaſon to ſuſpect, from the reſemblance betwe
general properties of lead and biſmuth, that th
of this ſemi-metal may be attended with noxious
ſimilar to thoſe which the calces of lead are kno
produce.

Solution in marine acid.

The marine acid does not readily act upon bi
It is neceſſary that the acid ſhould be concen
and kept a long time in digeſtion upon it; or
ſhould be diſtilled from the ſemi-metal. The r
when waſhed with water, affords a ſaline co
tion, which does not eaſily cryſtallize, but

BISMUTH.

'imed in the form of a ſoft fuſible ſalt, called
ter of biſmuth. The marine ſolution of biſmuth
wiſe affords a precipitate of calx by the addition
water. Marine acid ſeizes the calx of biſmuth,
n added to its ſolution in nitrous acid; and forms
ompound of ſparing ſolubility, which falls to the
om. Alkalis likewiſe precipitate its calx; but
of ſo beautiful a white colour as that afforded
he affuſion of pure water.

Habitudes of biſmuth with earths, ſalts, ſulphur:

he effects of earths and alkalis upon biſmuth, in
dry way, have been little attended to. Nitre cal-
es it, with ſcarcely any perceptible detonation. Sal
noniac is not decompoſed by biſmuth in the me-
c ſtate, though its calx readily combines with the
ine acid of that ſalt, and diſengages the volatile
li. Sulphur unites with biſmuth by fuſion, and
ns a blueiſh grey brilliant maſs, of a needle-formed
ure.

— and metallic ſubſtances.

his ſemi-metal unites with moſt metallic ſub-
ces; and renders them, in general, more fuſible.
en calcined with the imperfect metals, its glaſs
olves them, and produces the ſame effect as lead
cupellation; in which proceſs, it is even ſaid to
preferable to lead.

Uſes.

iſmuth is uſed in the compoſitions of pewter, in
fabrication of printers types, and in various other
allic mixtures.

Native biſmuth and its ores.

t is ſometimes found native, and may be analyſed,
the humid way, by ſolution in nitrous acid, and
cipitation, by the addition of water; which throws
vn 113 grains of calx for every 100 of metallic
nuth. It is likewiſe found in the calciform ſtate;

and mineralized by ſulphur, of a grey colour, reſem bling galena, but heavier. Theſe ores may alſo b analyſed by nitrous acid, like the foregoing.

Reduction of biſmuth ores.

Biſmuth is eaſily ſeparable, in the dry way, fron its ores, on account of its great fuſibility. It is uſual in the proceſſes at large, to throw the biſmuth or into a fire of wood; beneath which a hole is mad in the ground to receive the metal, and defend i from calcination. The ſame proceſs may be imitate in the ſmall way, in the examination of the or of this metal; nothing more being neceſſary than t expoſe it to a moderate heat in a crucible, with quantity of reducing flux; taking care, at the ſam time, to perform the operation as ſpeedily as poſſibl that the biſmuth may be neither calcined nor vol tilized.

C H A

CHAP. X.

CONCERNING NICKEL.

NICKEL.

Characters.

ICKEL is a reddiſh white metallic ſubſtance, of great hardneſs, and of an uniform texture; difficult to be purified, and always magnetical, nce it has been ſuppoſed to contain iron in its ſt ſtate. It is malleable, and is ſcarcely more le than pure iron. Its calces are of a green ur.

Treatment of the ores of nickel.

his metallic ſubſtance has not been applied to any and the chief attention of thoſe chemiſts who examined it has been directed to obtain it in te of purity; which, however, has not yet been mpliſhed. It is found either native or calciform; moſt commonly mineralized in combination with ic, ſulphur, cobalt, and iron, in the ore, called er nickel, or falſe copper. This is of a reddiſh w, or coppery colour; of a texture either uniform, ular, or ſcaly; bright in its fracture, and almoſt ys covered with a green efflorescence of calx. of the ſulphur and arſenic may be driven off by continued roaſting, and the occaſional addition arcoal, which prevents the arſenic from being ered more fixed by calcination; and the green which remains may be fuſed by the ſtrongeſt of a ſmith's forge, together with two or three its weight of black flux. The regulus thus

obtained

obtained is of a reddiſh white colour, and britt but is very far from being pure. Repeated cal nations for many hours, and reductions, ſcarc deprive the regulus of iron; and it is ſtill hig magnetic, when purified to ſuch a degree as to poſ conſiderable malleability. Combination with ſulph with liver of ſulphur, detonation with nitre, ſolution in the volatile alkali and vitriolic acid, not deprive it of its magnetiſm.

Pureſt regulus of nickel.

When the regulus [*], obtained by ſcorification reduction, was combined with ſulphur, and redu again after the diſſipation of the ſulphur by ſtr heat, and the addition of charcoal, to promote volatility of the arſenical contents; and this pro was three times repeated; the reduced metal wa infuſible, as not to run into a maſs by the ſtron heat of a ſmith's forge, continued for three qua of an hour. Its colour was then whitiſh, m with a glittering kind of red; it was ſtrongly netical; of a ſpecific gravity of 8.66; and a glo of one line in diameter was extended by the har into a plate of upwards of three lines in diameter that it is, properly ſpeaking, an entire metal, and a ſemi-metal. It afforded a blue ſolution with volatile alkali; and in nitrous acid its ſolution of a full green.

— Is an entire metal.

Action of vitriolic acid.

Concentrated vitriolic acid acts upon the re of nickel, and corrodes it. The reſidue, after di tion of the acid, is a greyiſh powder; part of w is in the ſaline ſtate, and affords green cryſta ſolution in water and evaporation.

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[*] Bergman on Nickel, in vol. ii. of his Eſſays.

NICKEL.

he nitrous ſolution of this metal affords ſaline
ſtals. Alkalis precipitate it, and rediſſolve the pre-
tate. Nitre detonates with nickel in the dry way.
phur readily combines with it by fuſion, as does
wiſe arſenic; and both adhere very pertinaciouſly
, as has been already ſhewn.

Whether nickel be truly a pecu-liar metal.

ickel has been thought to be a modification of
. This concluſion is grounded chiefly on its mag-
ſm, and the conſideration of the very remarkable
different properties iron is known to be capable
ſſuming, in its ſeveral ſtates. Others have ſup-
d it to be an alloy of copper with various me-
admixtures. The blue colour it affords with
tile alkali, is the chief circumſtance which gave
to this opinion. But it has been very properly
rved *, that many of the known metals would
ely have endured more ſevere trials than this
ance has undergone, without ſhewing indications,
aſt as ſtrong, againſt the ſuppoſition of their
g diſtinct bodies, as any afforded by nickel; and
equently, that ſo long as no one is able to pro-
this metal from pure iron or copper, and to
ain in an intelligible way the proceſs by which it
be generated, we muſt continue to regard it as a
liar ſubſtance, poſſeſſing diſtinct properties. The
ral opinions of chemiſts concur in admitting the
of this reaſoning.

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* Bergman, ii. 264.

CHAP. XI.

CONCERNING ARSENIC.

ARSENIC.
Characters.

ARSENIC in the metallic ſtate, or the regul of arſenic, is of a bright yellowiſh white colo ſubject to tarniſh, and grow black, by expoſure to a It is brittle, and when broken exhibits a laminat texture. In cloſe veſſels it ſublimes entire; but bur with a ſmall flame, if reſpirable air be preſent.

White calx of arſenic:

The arſenic met with in commerce has the form a white calx. It is brought chiefly from the cob works in Saxony, where zaffre is made. Cobalt o contain much arſenic, which is driven off by lo torrefaction. The ore is thrown into a furnace reſe bling a baker's oven, with a flue, or horizontal chi ney, nearly two hundred yards long; into which fumes paſs, and are condenſed into a greyiſh or bla iſh powder. This is refined by a ſecond ſublimat in cloſe veſſels, with a little pot-aſh, to detain the purities. As the heat is conſiderable, it melts ſublimed flowers into thoſe cryſtalline maſſes wh are met with in commerce.

— is in a ſaline ſtate.

The calx of arſenic is ſo far in the ſaline ſtate, a be ſoluble in about eighty times its weight of wa at the temperature of 60°, or in fifteen times its we of boiling water.

Regulus.

The regulus may be obtained from this calx, ei by quickly fuſing it together with twice its weigh ſoft ſoap, and an equal quantity of alkali, and pou

Regulus.

out, when fuſed, into an hot iron cone; or by xing it in powder with oil, and expoſing it in a traſs to a ſand heat. This proceſs is too offenſive be made but in the open air, or where a current of carries off the fumes. The decompoſed oil firſt es; and the regulus is afterwards ſublimed, in the m of a flaky metalline ſubſtance.

Action of vitriolic acid:

Vitriolic acid does not attack the regulus of arſenic, : its calx, when cold; but, if it be boiled upon s ſemi-metal, vitriolic acid air is emitted, a ſmall antity of ſulphur ſublimes, and the arſenic is re- ced to the calciform ſtate. Boiling vitriolic acid ſolves the calx of arſenic; but ſcarcely retains any :tion of it when cold. The calx of arſenic is con- :rably leſs volatile when vitriolic acid is preſent, or xed with it; but it is ſaid that waſhing deprives it the acid, and reſtores its properties.

— of nitrous acid:

Nitrous acid readily attacks and calcines the regu- of arſenic: it likewiſe diſſolves the calx of this ii-metal, in conſiderable quantity, by the aſſiſtance heat; and affords a cryſtallized deliqueſcent ſalt evaporation, which does not detonate on red hot ls. The calx of arſenic is acidified by the action nitrous acid diſtilled from it.

— of marine acid:

Boiling marine acid diſſolves the regulus, and alſo calx of arſenic; but affects it very little when d. This ſolution affords precipitates upon the ad- ion of alkalis.

— of aerate acid.

The dephlogiſticated or aërated marine acid con- ts the calx of arſenic into arſenical acid.

The calx of arſenic acts, in many inſtances, like acid. It decompoſes nitre by diſtillation; the

ARSENIC.
Page 213.

Diſtillation of calx of arſenic with ſulphur.

Orpiment and realgar.

nitrous acid flying off, and the arſenical ſalt of Macquer remaining behind. In this proceſs, the nitrous acid appears to acidify the calx. Quadrangular nitre is affected in the ſame manner. When the white calx of arſenic is diſtilled with ſulphur, volatile vitriolic acid flies off, and a combination of a yellow colour, called orpiment, is produced; which appears t conſiſt of ſulphur, united to regulus of arſenic; tha is to ſay, part of the ſulphur receives vital air from the calx; to which, according to the ancient ſyſtem it communicates phlogiſton: and in this manner th ſulphur becomes converted into vitriolic acid; whi the arſenical calx is reduced, and combines with th reſt of the ſulphur. The combination of ſulphur an arſenic which has been fuſed, is of a red colour; an known by the name of realgal, or realgar. Realg appears to be leſs volatile than orpiment, or the yello combination; for it remains at the bottom, while th other ſublimes: but in what reſpect they differ fro each other has not been well aſcertained. It is n improbable but that the orpiment may contain t calx in a more reduced ſtate than the realgar. ſtrong heat converts orpiment into realgar.

Liver of ſulphur.

Saline liver of ſulphur diſſolves the calx of arſeni but more readily attacks the regulus.

Fixed alkalis.

Watery ſolutions of fixed alkalis diſſolve the calx arſenic; and, if they be loaded with it by means heat, a brown tenacious maſs is produced, which a quires ſolidity, has a diſagreeable ſmell, and is call hepar of arſenic. Mineral acids precipitate part the arſenic; but a portion of it, being acidified, a heres more tenaciouſly to the alkali. The acids oc n no precipitation from the ſolution of arſenic in the latile alkali. It is not eaſy to explain what happens this caſe, without further experiments. The ſolu-

Combination of calx of arſenic, with alkalis:

ns of calx of arſenic in alkalis differ much in their operties from the combination which is produced hen the nitrous ſalts are decompoſed by its means. his difference is accounted for from the conſideration at it is the calx of arſenic in the firſt caſe, and the id in the latter, which combines with the alkalis.

— with metals.

A ſolution of the calx of arſenic acts upon metals the humid way, moſt probably in conſequence of s approach to the acid ſtate.

Action of arſenical acid— Page 213.

—on gold, platina: —ſilver:

— mercury.

The acid of arſenic being applied to the filings of e metals, in a long-necked flaſk, to prevent its re- ction, acts upon ſeveral of the metals in a digeſting eat. Gold and platina are ſcarcely acted upon. Sil- er is not attacked by digeſtion; but when the acid omes to be fuſed, the metal is diſſolved, and affords a lourleſs glaſs, which is nearly tranſparent; ſoluble water, with the loſs of greateſt part of the ſilver, hich ſubſides in the form of a brown powder, con- ining a minute portion of the acid; and reducible, ke the other precipitates of ſilver, by mere heat. ercury is not attacked by the arſenical acid, in the eat of digeſtion; but when the acid and mercury e urged in a retort, by an heat which is near melting e veſſel, part of the mercury combines with the id, and forms a yellowiſh maſs of extremely difficult ſion; very fixed, and inſoluble in water. Diluted itrous and vitriolic acids have ſcarcely any effect on , but marine acid readily diſſolves it. This ſolution, y evaporation to dryneſs, and diſtillation, affords

Action of arſenical acid on copper:

— on iron:

— on lead:

corroſive ſublimate, and the reſidue is arſenical acid; whence it follows, that the mercury in the arſenical combination muſt have been perfectly calcined. Copper is diſſolved by the arſenical acid in digeſtion, and affords a green ſolution. One part of copper filings, mixed with two of dry arſenical acid, affords a blue maſs by fuſion, at an elevated degree of heat, which is ſoluble in water; and then proves to be the ſame combination as was produced by digeſtion. The watery ſolution lets fall a light blue powdery matter conſiſting of a combination of copper with arſenical acid. Iron likewiſe is attacked by this acid during digeſtion; and the whole ſolution at laſt grows gelatinous, if the digeſtion be performed in an ope veſſel. If the digeſtion be performed in a long necked or cloſe veſſel, it does not become gelatinous; but will afterwards become ſo, if expoſed t the air. In the dry way, when one part of iro filings is diſtilled with four of acid of arſenic, th maſs makes a great effervefcence towards the end and, when it becomes dry, it takes fire upon increaſing the heat; arſenic and regulus of arſen being ſublimed, and a black friable reſiduum bein left at the bottom, which contains but little acid arſenic. In this proceſs it appears that the iro which is a metal very much diſpoſed to combuſtic or calcination, ſuddenly deprives the arſenical ac of its vital air, and reduces it to the ſtate of calx a regulus; at the ſame time that, according to t ancient hypotheſis, phlogiſton paſſes from the met to the acid. Little effect is produced upon lead digeſtion with the arſenical acid; but the combinati

tak

Action of arſenical acid on tin:

place by fuſion in the dry way, which affords
i-opake glaſs. When this is boiled in diſtilled
, the lead falls down in the form of a white
er, containing arſenical acid, but which does not
arſenic by heat, unleſs charcoal be added. Tin,
ed with arſenical acid, grows black at firſt;
vards becomes covered with a white powder;
at laſt, the whole maſs becomes gelatinous. In
ry way, one part of tin filings, with two of
id, heated in a retort, took fire when ignited:
he calx of regulus of arſenic immediately ſub-
, leaving a limpid ſolution of tin; which, when
l, was of a milky colour. This, when diſſolved
illed water, depoſited a white calx, which con-
very little acid of arſenic.

— on zinc.

c is the only metallic ſubſtance which effer-
when digeſted with the arſenical acid. The
rows black; and the tranſparency of the acid
royed by a quantity of black powder; which,
mination by burning on a red hot iron, proves
regulus of arſenic. This precipitated regulus
efends the zinc from farther ſolution. The
ich eſcapes during the effervefcence is inflam-
holding regulus of arſenic in ſolution, which
ſits on burning. Either of the chemical the-
vill ſerve to explain theſe effects: for the zinc
ined by receiving the vital air of the acid;
t is ſuppoſed to give out phlogiſton enough to
the acid baſis to a regulus, and to afford the
nable air which eſcapes. Or, in the other
it will be ſaid that the zinc, having a ſtrong
cy to combine with vital air, and become cal-
cined,

ARSENIC.

Action of arſenical acid on zinc.

Theory.

cined, cannot decompoſe water at a moderate tem
perature, unleſs an acid be preſent, to remove th
coating of calx by ſolution as faſt as it is forme
which mere water cannot do. This therefore is t
firſt conſequence of the mutual action of wate
zinc, and the acid; namely, vital air quits the w
ter to unite with the zinc, and inflammable air fl
off at the ſame time that the acid combines with t
calx of zinc. But of the two metallic baſes, wh
are here combined by the intermedium of vital
the zinc has a ſtrong tendency to calcination, and
arſenic to become revived: it appears theref
from the facts, that the zinc, attracting the vital
moſt ſtrongly, becomes ſtill more calcined, and c
ſequently leſs ſoluble; while the arſenic is red
by the loſs of its vital air. Whence it muſt fol
that the metallic zinc which remains, being e
loped with calx of zinc and metallic arſenic, ca
longer be acted on by the acid and water which

Caution reſpecting theories.

continue undecompoſed. On this, and ſimilar
ſions, it cannot however be too often repeated to
chemical ſtudent, that theories ought to be caut
followed, as of uſe in the arrangement of facts
in directing the path to future inveſtigations;
diſcriminating phenomena ought to be earneſtly ſ
after, becauſe of infinitely more value than the
ingenious ſpeculations; and that an attachme
ſyſtem, though it frequently gives life and enc
the exertions of genius, is in general a certain
of prejudices, which diſable the enquirer from
ſuing the ſearch after truth, and fix his mind
words inſtead of things.

Action of arſe-nical acid on zinc;

ı the dry way, when one part of the filings of · was mixed with two of the arſenical acid, and lled, the maſs took fire, with a very bright inflam-ion, as ſoon as the retort became red hot. The ·l was burſt by the exploſion; and in its neck : found regulus of arſenic, and flowers of zinc. ; effect may be explained from the ſame conſide-ns as were applied to the combuſtion which takes :, in like circumſtances, with iron.

Page 360.

— on biſmuth;

iſmuth is acted upon by the arſenical acid in ſtion. Water precipitates a powder from the :ion, which conſiſts of acid of arſenic, combined . calx of biſmuth. In the dry way, biſmuth ılcined by this acid, but not diſſolved; a little ıic being ſublimed: and, if water be added to cooled maſs, the acid is taken up, but the calx ins. Regulus of antimony is affected nearly in ſame manner as biſmuth, in the humid way; in the dry way, an inflammation takes place at :ime of fuſion. By digeſtion with cobalt, the of arſenic aſſumed a roſe colour; but much of :obalt remained undiſſolved. The whole maſs ; diſtilled to dryneſs, and fuſed, afforded glaſs of ›let colour, and ſemi-tranſparent. Nickel com-cates a green colour to this acid by digeſtion; antity of green powder, mixed with arſenic, be-recipitated: the arſenic may be ſeparated by a e heat. In the dry way, the acid combines nickel, and forms a yellow maſs, with grey ‹s upon it, reſembling a vegetation. By boiling ater, the acid is taken up, and a yellow powder

— on antimony;

— on cobalt:

— on nickel.

Action of arſenical acid on manganeſe.

left behind, conſiſting of a combination of nickel a arſenic, moſt probably in the acid ſtate: the arſe is reduced with charcoal, but the nickel is not. C of manganeſe is ſcarcely acted upon by acid of ar nic; but, when the manganeſe is partly or entir reduced, it is diſſolved in the humid way; and affo cryſtals as ſoon as the acid is nearly ſaturated. T regulus, digeſted with the arſenical acid, beco covered with a white powder of arſenical c When one part of the regulus was mixed with parts of the dry acid, and expoſed to diſtillat the regulus was ſublimed before the heat was ſ ciently great to fuſe the acid, and conſequently mutual action took place; but when the acid firſt fuſed, and the regulus added ſucceſſively in ſ lumps, inflammation took place, and calx of arſ was ſublimed.

Combinations of regulus of arſenic.

Regulus of arſenic is ſoluble in unctuous oils, boiling heat: the ſolution is black, and has the ſiſtence of ſalve when cold *. Moſt metals unite arſenic; which moſt probably exiſts, in the line ſtate, in ſuch as poſſeſs the metallic brilli The calx, more or leſs acidified, is common in minerals.

Uſes of arſenic.

Arſenic is uſed in a variety of arts. It enters metallic combinations wherein a white colour quired. Glaſs manufacturers uſe it; but its

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* On arſenic and its acid, conſult Scheele's Eſſays, p Bergman's Eſſays, vol. ii.; Pelletier, in the Journal de P for 1782, &c. &c.

ARSENIC.

the compoſition of glaſs does not ſeem to be rly explained. Orpiment and realgar are uſed as nents. Some attempts have been made to intro- it into medicine; but, as it is known to be a t violent poiſon, it is probable that the fear of its effects may long deprive ſociety of the advantages ight afford in this way.

CHAP. XII.

CONCERNING COBALT.

COBALT.

Characters of cobalt.

COBALT is a ſemi-metal, of a whitiſh gre or ſteel colour; hard, brittle; of a dull, cloſ grained fracture, and moderate ſpecific gravity. It rather more difficult of fuſion than copper; does n eaſily become calcined; and its calx is of ſo dee a blue colour, as to appear black. The moſt remar able and moſt valuable property of this metallic ſu ſtance is, that its calx, when fuſed with borax, with alkali and ſand, produces a blue glaſs, known the name of ſmalt. The action of air ſoon tarniſ it; but water has little or no effect upon it.

Combination with vitriolic acid:

Concentrated and boiling vitriolic acid, diſtil nearly to dryneſs, combines with this ſemi-me Much vitriolic acid air flies off; and the cobalt is part calcined, and in part converted into a cryſ lizable ſalt, ſoluble in water, and precipitable by l and by alkalis in the form of a roſe-coloured pow or calx. Diluted vitriolic acid acts upon the cal cobalt, and forms the ſame ſalt.

—with nitrous acid.

Nitrous acid diſſolves cobalt by the aſſiſtance a moderate heat. Nitrous air is diſengaged; and ſolution affords deliqueſcent cryſtals by evaporat which do not detonate on ignited coals, but boi and leave a red calx. Lime, and the alkalis, cipitate the ſolution; and, if the alkali be adde exceſs, it diſſolves the precipitate.

Combination with marine acid:

he marine acid has ſcarcely any action on co-
unleſs it be boiling; in which caſe it diſſolves a
l portion. It diſſolves the calx more readily;
which it forms a red brown fluid, that becomes
n when heated. This ſolution affords deliqueſ-
cryſtals by evaporation.

— with aqua regia.

Sympathetic ink.

qua regia diſſolves cobalt more eaſily than the
ne, though not ſo readily as the nitrous, acid.
ſolution is well known, as one of the moſt cele-
d ſympathetic inks afforded by chemiſtry. If it
luted with a ſufficient quantity of water to pre-
its action upon paper, and then uſed to write
, the letters are inviſible as ſoon as the clear
ion has become dry: but, if the paper be held to
re for a ſhort time, they appear of a fine green
r; which again diſappears by removing it, and
ing it to cool again. If the heat be continued
ng after the letters appear, it will render them
anent. This effect ſeems to be analogous to
which obtains in the marine ſolution: but none
e efficient cauſes of change of colour in this, or
ther chemical phenomenon, have been hitherto
ined.

Acid of borax and cobalt.

e acid of borax does not act immediately on
, in the humid way: but borax itſelf, added to
of the foregoing ſolutions, effects a decompo-
by double affinity; the alkali uniting with the
it acid, while the acid of borax ſeizes the cobalt,
orms a ſcarcely ſoluble compound, which falls
.

Acid of ſugar.

e acid of ſugar precipitates cobalt from its ſolu-
in the form of a pale roſe-coloured powder.

Whether

Habitudes of cobalt:

Whether alkalis or earths combine with this metal directly, by the intervention of water, has not been determined.

— with nitre:

Cobalt does not act on neutral ſalts in general. I detonates feebly with nitre, when projected into red hot crucible, with twice or thrice its weight o that ſalt. The metal becomes calcined by the actio of the nitre; but the changes in both ſubſtances re quire farther examination.

— with ſal ammoniac:

Sal ammoniac is not decompoſed by cobalt.

— with ſulphur:

Sulphur does not unite with cobalt, but with diſſ culty. Liver of ſulphur combines more readily wi it. The action of phoſphorus, or its acid, on t ſubſtance, remains to be aſcertained.

— with metallic ſubſtances.

This ſemi-metal unites by fuſion with moſt of t metals and ſemi-metals, as has before been notic Silver, lead, and biſmuth, do not mix with it; a zinc does not but with great difficulty.

Native cobalt and its ores.

Cobalt is found native in alloy with arſenic and ir and of a ſteel-grained appearance when broken; o a calciform ſtate, of a black colour, either pulve lent or indurated: or combined with arſenical acid the flowers of cobalt, of a red colour; or, laſtly, uni to ſulphur and iron, with or without arſenic, of rious ſhades of redneſs. Biſmuth, nickel, and ot ſubſtances, are contained in theſe ores. They in general be diſtinguiſhed by ſolution in aqua reg with which, after dilution with water, they form ſympathetic ink above deſcribed.

Humid analyſis.

The native cobalt, and its calciform or ſul reous ores, may be examined by ſolution in a regia, and evaporation to dryneſs; after which,

calc

Humid analyſis of cobalt ores.

ined cobalt may be diſſolved by vinegar. When
calx is precipitated by mild mineral alkali, the
ılus may be accounted for, by allowing one hun-
d grains for every hundred and ſixty grains of
cipitate. The other component parts of the reſi-
, not taken up by the vinegar, may be aſcertained
he methods deſcribed in the preceding chapters.
red arſenical cobalt ore, which contains arſenical
, may be decompoſed by vitriolic acid; and the
ngaged arſenical acid will be taken up by highly-
ified ſpirit of wine; after which, the combination
itriolic acid and cobalt may be diſſolved in water,
precipitated by mild alkali: or the ore itſelf may
liſſolved in water, ſharpened by an acid; and the
be then precipitated by the alkali.

Analyſis in the dry way.

the dry way, the ores of cobalt, after previous
ıding, waſhing, and roaſting, may be fuſed with
times their weight of black flux, in a lined
covered crucible, by the heat of a ſmith's forge.
tinging power of cobalt ores may be aſſayed by
n with three parts of fixed alkali, and five of
lered flint, or glaſs. The alkali muſt be put firſt
the crucible; next, the flint; and, above all,
roaſted ore. When cobalt ores, containing biſ-
, are reduced, this ſemi-metal uſually occupies
ower part of the crucible, and may be ſepa-
from it by a blow with a hammer; or at
by eliquation, or melting, on account of its
er fuſibility.

Cobalt found moſt plentifully in Saxony.

balt is found in ſeveral parts of Europe, but
plentifully in Saxony. The ore is uſually broken

Manufacture of zaffre and ſmalt.

into pieces about the ſize of a hen's egg, and th ſtony parts picked out. The ſorted mineral is then pounded in mills, and ſifted through wire ſieves. By waſhing in water, the lighter parts are carried off; and the remainder is calcined in a furnace reſembling an oven, wherein it is heated by the action of th reverberated flame of wood which plays upon it. I this ſituation, it is occaſionally ſtirred with long iro rakes; and emits fumes, conſiſting chiefly of arſeni which is collected in a long horizontal chimney, bui for that purpoſe. If the ore contain biſmuth, th fuſible ſemi-metal is collected at the bottom of t furnace. The cobalt, after a ſufficient torrefactio remains in the form of a dark grey calx, call zaffre. The zaffre of commerce always contai twice or thrice its weight of powdered flints. T flint is pulverized, for this and other purpoſes, means of previous ignition, and quenching in wat which renders it friable. Smalt is a blue glaſs, co poſed of one part of the calcined cobalt, fuſed w two of the flint powder, and one of potaſh. Po der blue, or azure, is obtained by grinding ſmal mills, and afterwards waſhing it in water. This operation is performed in a caſk filled with ter, and pierced with three openings at differ heights. The water of the uppermoſt cock car out the fineſt blue, which they call azure of the fire. The larger particles fall more ſpeedily, the azure brought out by the water of the t cocks forms the different degrees of fineneſs kn under the names of azure of the firſt, ſecond, third fires.

The uſe of this metallic ſubſtance is confined efly to the production of the blue glaſs for ena-s, and other purpoſes. Powder and ſtone blue, l by laundreſſes, is a preparation made by the ch from the coarſe ſmalt.

Uſes of cobalt.

CHAP. XIII.

CONCERNING ZINC.

ZINC.
Characters of zinc.

ZINC is a ſemi-metal, of a blueiſh white colou ſomewhat brighter than lead; of conſiderab hardneſs; and ſo malleable, as not to be broken wi the hammer, though it cannot be much extended this way. It is very eaſily extended by the rollers the flatting mill. When broken by bending, its te ture appears as if compoſed of cubical grains. O account of its imperfect malleability, it is difficult reduce it into ſmall parts by filing or hammeri but it may be granulated, like the malleable meta by pouring it, when fuſed, into cold water; or, if be heated nearly to melting, it is then ſufficien brittle to be pulverized. It melts long before ig tion, at about the 700th degree of Fahrenheit's th mometer; and, ſoon after it becomes red hot, it bu with a dazzling white flame, of a blueiſh or yellow tinge, and is calcined with ſuch rapidity, that it f up in the form of white flowers, called the flower zinc, or philoſophical wool. Theſe are generated plentifully, that the acceſs of air is ſoon intercept and the combuſtion ceaſes, unleſs the matter be ſtir and a conſiderable heat kept up. The white cal zinc is not volatile, but is driven up merely by force of the combuſtion. When it is again urge a ſtrong heat, it becomes converted into a clear ye

g

ſs. If zinc be heated in cloſed veſſels, it riſes
hout decompoſition. Zinc appears to be the moſt
tile of metallic ſubſtances, except the regulus of
nic.

Solution of zinc in vitriolic acid.

he diluted vitriolic acid diſſolves zinc; at the
e time that the temperature of the ſolvent is in-
ſed, and much inflammable air eſcapes: an un-
lved reſidue is left, which conſiſts of plumbago.
theories of this ſolution, and the diſengagement
nflammable air, are perfectly ſimilar to thoſe which
e been before explained in the chapter on iron.
the combination of the vitriolic acid and the calx
ceeds, the temperature diminiſhes; and the vitriol
inc, which is more ſoluble in hot than cold water,
ns to ſeparate, and diſturb the tranſparence of the
l. If more water be added, the ſalt may be ob-
ed in fine priſmatic four-ſided cryſtals. The
e vitriol, or copperas, uſually ſold, is cryſtallized
ily, in the ſame manner as loaf ſugar, which, on
account, it reſembles in appearance: it is ſlightly
reſcent. The white calx of zinc is ſoluble in the
olic acid, and forms the ſame ſalt as is afforded
inc itſelf.

Page 296.

White vitriol.

Solution of zinc in nitrous acid:

iluted nitrous acid combines rapidly with zinc,
produces much heat, at the ſame time that a large
ntity of nitrous air flies off. The ſolution is very
tic, and affords cryſtals by evaporation and cool-
which ſlightly detonate upon hot coals, and leave
x behind. This ſalt is deliqueſcent.

—in marine acid.

arine acid acts very ſtrongly upon zinc, and diſ-
ges much inflammable air; the ſolution, when
orated, does not afford cryſtals.

Water impregnated with fixed air diſſolves a conſiderable proportion of zinc. The other acids hav not been tried.

Habitudes of zinc:

Zinc is precipitated from acids, by the ſolubl earths, and the alkalis: the latter rediſſolve the precipitate, if they be added in exceſs.

— with vitriolic ſalts:

Zinc decompoſes, or alters, the vitriolic neutral ſal in the dry way. When fuſed with vitriolated tartar, converts that ſalt into liver of ſulphur; the zinc at t ſame time being calcined, and partly diſſolved in t hepar. In this operation, the vital air of the ac combines with the zinc, and calcines it; at the ſa time that, according to the ancient theory, the ph giſton of the metal combines with the acid baſe, a converts it into ſulphur. In the new theory, tranſition of phlogiſton is conſidered as hypotheti and unneceſſary: becauſe, the metal and the ſulph being taken to be ſimple ſubſtances, the vitriolic a becomes ſulphur, merely by the loſs of its vital a and the zinc becomes calcined, merely by the acc ſition of the ſame ſubſtance.

— with nitre:

When pulverized zinc is added to fuſed nitre, projected together with that ſalt into a red hot cible, a very violent detonation takes place; inſom that it is neceſſary for the operator to be carefu uſing only ſmall quantities, leſt the burning m ſhould be thrown about. The zinc is calcined; part of the calx combines with the alkali, with w it forms a compound, ſoluble in water.

— with common ſalt; ſal ammoniac; and alum.

Zinc decompoſes common ſalt, and alſo ſal am niac, by combining with the marine acid. The ſ of zinc likewiſe decompoſe alum, when boiled

ſo

lution of that ſalt, probably by combining with its ceſs of acid.

Habitudes of zinc with ſulphur:

Sulphur, though its action is almoſt general on me- llic ſubſtances, does not combine with zinc. This operty affords a ready means of purifying the ſemi- etal, by projecting ſulphur upon it, when melted in ſhallow crucible. It has been a ſubject of remark, nong chemiſts, that many of the zinc ores conſiſt this ſemi-metal combined with ſulphur, though art as not yet diſcovered the means of effecting the ſame mbination. But the difficulty is removed by the nſideration, that the ſulphur does not unite with nc itſelf, yet it readily does with its calx, and forms compound ſimilar to the zinc ores, called blendes; which, for that reaſon, the zinc may be preſumed exiſt in the calciform ſtate.

— with liver of ſulphur:

Liver of ſulphur does not combine with zinc, either the humid or dry way.

— with metals.

Moſt of the metallic combinations of zinc have en already treated of. It forms a brittle compound th antimony; and its effects on manganeſe, wol- am, and molybdena, have not yet been aſcertained.

Native zinc and its ores.

Native zinc has been very ſeldom found. The lciform ores of zinc are the zinc ſpar, of a hitiſh grey colour, reſembling a lead ſpar; and the ipure calx called calamine, which is of a white, ey, yellow, brown, or red colour, containing iron, ay, calcareous and other earths, and lead. The e called blende, mock lead, or black jack, conſiſts zinc mineralized with ſulphur and iron: of this ere are ſeveral varieties. They are in general of plated texture; and frequently of a quadrangular form,

form, like galena, or potters' lead ore, though they are conſiderably leſs heavy. Theſe ores are found in various parts of Europe; and, in conſiderable plenty, in the mine counties of England.

Humid analyſis of zinc and its ores.

Native zinc may be aſſayed, in the humid way, by the mineral acids. When it is diſſolved in theſe, if there be any other metal preſent, it may be precipitated by the addition of a known quantity of zinc. The weight of calx of zinc precipitated by mild alkali from its vitriolic ſolution, will amount to 193 grains for every 100 of the metal it repreſents. The ſulphureous zinc ores muſt be carefully treated with nitrous acid; which will diſſolve the zinc, and leave the ſulphur. Extraneous metals may be precipitated, and the quantity of zinc aſcertained, as before.

Eſſay of calamines.

The eſſay of calamines is ſometimes made by pounding and mixing them with charcoal, and then heating them in a crucible covered with a copper plate. The reduced zinc riſes, and converts the copper into braſs; and, in this way, ſome judgment may be formed of its value in the operation of braſs-making Moſt of the zinc, whether in the metallic ſtate, or in the form of an impure calx, called cadmia fornacum is obtained in the roaſting of various kinds of ore at Ramelſburg. For this purpoſe, the anterior pa of the furnace is kept cold by wetting it: by which means the volatilized zinc is condenſed, and fall into a cavity, containing charcoal duſt, which defend it from calcination.

Diſtillation of zinc.

The proceſs for obtaining zinc from its ores b diſtillation, which is practiſed in England, and sai to have originally been derived from the Chineſe, i performe

ZINC.

ormed in a furnace, in the form of a circular
; in which are placed ſix pots, each about four Diſtillation of zinc.
in height, and of a conical ſhape, reſembling an
jar. Into the bottom of each pot an iron tube
ſerted, which paſſes through the floor of the
ace into a veſſel of water. Theſe pots are filled
a mixture of calamine and charcoal; and their
ths are then cloſe ſtopped with clay. The fire
then properly applied, the metallic vapour of
alamine iſſues through the iron tube, which is
nly place where it can eſcape. In this way it is
enſed in ſmall particles in the water; which are
wards melted into ingots for ſale, under the name
pelter *. The ſubſtance ſold in London by the Spelter.
of ſpelter, is a kind of ſoft braſs, in a granu-
form, which is uſed by the braziers and others
ldering.

e chief purpoſe to which zinc is applied conſiſts Uſe of zinc. Page 258.
e fabrication of braſs, and other gold-coloured
ures. Its calces and ſalts have been occaſionally
yed in medicine.

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* Watſon's Chemical Eſſays, vol. iv.

CHAP.

CHAP. XIV.

CONCERNING ANTIMONY.

ANTIMONY.

Characters of antimony.

REGULUS of antimony is of a ſilvery whi colour; very brittle, and of a plated or ſca texture. Its ſpecific gravity is moderate. Soon af ignition it melts; and, by a continuance of the he it becomes calcined, and riſes in white fumes, whi may afterwards be volatilized a ſecond time, or fu into a hyacinthine glaſs, according to the mana ment of the heat: they are called argentine flowers regulus of antimony. In cloſed veſſels, the regu riſes totally without decompoſition. This meta ſubſtance is not ſubject to ruſt by expoſure to a though its ſurface becomes tarniſhed by that me Its calces are ſoluble in water; and, in that reſp reſemble the calx of arſenic, probably by an appro towards the acid ſtate.

Action of vitriolic acid on antimony.

Vitriolic acid, boiled upon the regulus of antim calcines the greater part, ſo as to render it inſ ble; the acid being at the ſame time decomp Much vitriolic acid air eſcapes; and, towards the a ſmall quantity of ſulphur is ſublimed. By waſ the reſidue in water, a vitriolic ſalt of antimo ſeparated from the calx, which does not cryſtalliz

Nitrous acid.

Nitrous acid very readily attacks antimony in cold. Moſt part of the metal is calcined by action; but a portion is diſſolved, and affords queſcent cryſtals, decompoſible by heat. The

ntimony formed by this acid, is very white, and
cult of reduction.

Solution of antimony in marine acid:

ontinued digeſtion is required for the ſolution of
ulus of antimony in the marine acid. A conſide-
e quantity is however at length diſſolved; which
rds very deliqueſcent cryſtals. This ſalt melts by
application of heat; and is decompoſed by diſtilled
er, in the ſame manner as the butter of antimony,
n which it does not much differ.

— in dephlogiſticated or aerated marine acid:

ephlogiſticated, or aërated marine acid diſſolves
regulus of antimony with great facility.

— in aqua regia.

qua regia, compoſed of ſeven parts nitrous, and
marine acid, diſſolves it very readily; but lets
a portion of white calx as it cools. The ſolvent
er of either of the three ancient mineral acids on
ſemi-metal, appears to be increaſed by mixture
any one of the others.

Habitude of regulus of antimony with earths;

arthy ſubſtances do not act on the regulus of anti-
y in the dry way. Its calx, however, enters rea-
into the compoſition of glaſs; to which it imparts
e or leſs of an hyacinthine colour. When fuſed
vitriolated tartar, it converts it partly into hepar,
iver of ſulphur; which diſſolves a portion of the
of antimony: that is to ſay, the vital air of the
calcines the regulus of antimony, while part of
acid becomes converted into ſulphur; either ſimply
the loſs of its vital air, or elſe by that loſs, together
h the acquiſition of phlogiſton from the regulus.

— with vitriolated tartar.

Detonation with nitre.

itre detonates very readily with the regulus of
mony: when equal parts of theſe ſubſtances are
jected into a red hot crucible, the reſidue of calx
alkali is known by the name of diaphoretic anti-

mony. When the ſaline part is waſhed out by hot water, the reſidue is called waſhed diaphoretic antimony. The water uſed in the waſhing contains a portion of the calx, ſuſpended by the alkali. This may be precipitated by the addition of an acid, and has been diſtinguiſhed by the name of ceruſe of antimony.

Diſtillation of regulus of antimony with corroſive ſublimate.

When regulus of antimony is pulverized, and accurately mixed with about twice its weight of corroſiv ſublimate, a mutual action takes place with the pro duction of heat; and, if the mixture be diſtilled wit a gentle fire, a thick fluid comes over, which con geals in the receiver, or in the neck of the retor

Butter of antimony.

and is called butter of antimony. The reſidue con ſiſts of revived mercury, and ſome regulus and cal

Theory.

of antimony. In this experiment, the dephlogiſt cated marine acid combines with the antimony, whi the mercury is revived; as may be eaſily explained o either of the two theories of chemiſtry. If the com bination of regulus of antimony and ſulphur be uſe inſtead of the regulus itſelf, the mercury will be o tained in the form of cinnabar, at a much great heat than is required to ſublime the butter of ant mony.

Powder of algaroth.

When butter of antimony is thrown into pure w ter, an abundant white precipitate, or calx, falls dow which is a violent emetic, and is known by the na of powder of algaroth.

Bezoar mineral.

Nitrous acid diſſolves the butter of antimony. T ſolution, which does not appear to differ greatly fro the ſolution of the regulus in aqua regia, ſoon d poſits a portion of calx. When an equal weight

nitro

ous acid has been three times diſtilled to dryneſs
n butter of antimony, the reſidue, after ignition,
alled bezoar mineral; and ſeems to be little more
a calx of the metal.

Combination of regulus of antimony with ſulphur:

ulphur combines very readily with the regulus of
mony, and forms a ſubſtance differing in no re-
t from the mineral, or ore, to which the name of
nony is excluſively appropriated. One part of
hur completely mineralizes four of the regulus.

— with liver of ſulphur.

iver of ſulphur diſſolves the regulus of antimony,
affords an orange-coloured precipitate upon the
tion of an acid.

Crude antimony:

ntimony, or the regulus combined with ſulphur,
a favourite object of reſearch in the experiments
e alchemiſts; in conſequence of which, its pro-
es are much better known than thoſe of the pure
lus.

—its habitudes;

If this ſubſtance be heated, it melts, and
nſiderable portion of the ſulphur flies off, at the
time that the regulus becomes calcined, and
in white vapours.

by heat:

A gentler heat, leſs than is
ſſary to fuſe it, converts it into a grey calx:
calx contains a portion of ſulphur. If it be
d by a ſtronger heat, it melts into the form of
, which is more or leſs tranſparent, according
e degree of calcination of the metal, and the
ation of the ſulphur. When it contains much
ur, the glaſs is fuſible, opake, and of a dark
colour; whence it has been called liver of anti-
.

— with acids.

hen acids are applied to crude antimony, they
ve the regulus, and leave the ſulphur. The
us acid is beſt adapted to this ſolution.

Diaphoretic antimony.

Diaphoretic antimony is moſt commonly and a vantageouſly prepared by detonating the crude ant mony with nitre inſtead of the regulus: the on difference being, that more nitre is required for t detonation; and that the reſidue contains vitriolat tartar, as well as alkali and calx.

Antimonial medicines.

There are ſeveral preparations, conſiſting of com nations of antimony with an alkali, in which the pr portions of the ingredients, and the ſtate of the ca are very different, according to the nature and m nagement of the proceſſes. Many of theſe have be highly praiſed in medicine; at the ſame time that t have been as ſtrongly exclaimed againſt for their effects. Both theſe aſſertions appear to have be well founded. It is ſufficiently proved that anti nial medicines have produced the happieſt effe and are juſtly entitled to be conſidered as very pow ful remedies; but, on the other hand, it is equ certain, that their great efficacy muſt have requi greater attention, in their firſt exhibition, than haps may have been paid; and the complicated nat of many of the proceſſes muſt have rendered it v difficult to produce ſubſtances poſſeſſing exactly ſame properties, or proportion of component p at all times.

Kermes mineral.

If antimony be treated with a fixed alkali, eithe fuſion and ſubſequent ſolution in boiling water, o ſimple ebullition, a precipitate is afforded by cool which is called kermes mineral, formerly uſed in dicine. It is thought to conſiſt of the calx of antim in combination with a portion of ſulphur; bu component parts have not been accurately determ its properties differ according to the various me- ls uſed in preparing it.

Antimonial medicines.

Emetic wine.

Antimoniated tartar.

he antimonial preparations moſt commonly uſed reſent are, antimonial wine, and emetic tartar. ſe, like every other preparation of this ſemi-metal, prepared in a variety of ways. The wine may ad by infuſing pulverized glaſs of antimony in iſh white wine for ſome days, and then filtering clear fluid through paper. A very minute por- of the calx is taken up; and this is greater or according as the wine is more or leſs acid; and aps, according to the temperature of the weather he time of adminiſtering it. On this account, it und neceſſary to give this medicine cautiouſly, by ſmall portions at a time, when it is intended it ſhall act as an emetic. The emetic or anti- iated tartar of the London College is thus pre- d:—Take of crude antimony and nitre equal , ſeparately reduced to powder; mix them, and t them into a crucible heated to whiteneſs, that mixture may melt after deflagration; pour it and reſerve the yellow maſs beneath the ſco- under the name of crocus of antimony; reduce to a very ſubtile powder; boil it in water, and the powder repeatedly in warm water, till it nes perfectly inſipid: then take equal parts, by ht, of the waſhed crocus of antimony and of cryſ- of tartar, and boil them together, in three pints ater for every pound of the mixture, during half ur: filter the liquor; and, after due evaporation, t by to cryſtallize.—This is the antimoniated . It is a triple ſalt, conſiſting of the acid of tartar,

tartar, united to vegetable alkali, and antimony par
tially calcined; and is conſidered as a ſafe medicin
whoſe properties and effects are more conſtant, an
milder, than moſt other antimonial remedies.

Medical effects of antimony.

It has not been clearly determined on what circu
ſtances the medical effects of antimony depend. T
ſaline preparations of mercury, and other meta
are ſuppoſed to derive their cauſticity from th
tendency to become reduced to the metallic ſtate;
conſequence of which, they corrode and decomp
other combuſtible ſubſtances: but whether this
the caſe with antimony, is doubtful. It appears
ceſſary, however, that antimony ſhould be in the ſal
ſtate, in order that it may act upon the animal ſyſte
When the regulus is made into thoſe ſmall balls
pills, which, on account of the little change they
dergo in paſſing through the human body, have b
called perpetual pills, its purgative action is mor
leſs violent, according to the quantity of acid it m
with; and, in the preparations of this ſemi-metal, t
effects ſeem likewiſe to be governed by the ſame
cumſtance joined to their reſpective degrees of ſ
bility. The nearly pure and inſoluble calx, produ
by detonation with a large proportion of nitr
almoſt ineffectual; whereas the more ſoluble calce
combinations are more or leſs active, accordin
their reſpective nature. Hence it appears to foll
that the ſimpleſt ſaline combinations are the
likely to produce effects conſtantly ſimilar; and
moſt of the calces and combinations, ſo highly
tolled in the earlier age of chemiſtry, are atte
with dangerous uncertainty in their operation.

Perpetual pills.

Anti

ntimony combines with moſt other metallic ſub-
ices, and produces mixtures whoſe properties have
n attended to under their reſpective titles.

Native antimony and its regulus.

ntimony is found either native, in maſſes of the
ılus, compoſed of ſhining irregular plates; or cal-
rm, in white cryſtallized filaments; or combined
ı ſulphur, in the dark blueiſh or grey friable
eral, called antimony, conſiſting moſt commonly
rilliant filaments diſpoſed parallel to each other;
laſtly, combined with ſulphur and arſenic, in an
which greatly reſembles the foregoing, except that
of a red or reddiſh colour.

Humid analyſis.

ative regulus of antimony, or its calx, may be
ed by nitrous acid, which diſſolves whatever arſe-
it may contain, and only calcines the antimony.
ſulphureous antimonial ores are moſt conveniently
yſed by aqua regia, which takes up the calx, and
es the ſulphur, which may be ſeparated by filtra-
. The remaining ſolvent may be examined with
ıuſual precipitants. In the dry way, antimony is
rated from its ſtony parts by fuſion in a moderate
, nearly in the ſame manner as biſmuth; and may
educed, by ſlowly roaſting it, till it becomes con-
ed into a grey calx, which may be briſkly fuſed
twice its weight of black flux.

Dry way.

Page 352.

Uſes.

ntimony and its regulus are chiefly uſed in me-
ıe, and in ſome metallic alloys, ſuch as that uſed
rinters types, ſmall ſhot, &c.

CHAP. XV.

CONCERNING MANGANESE.

MANGANESE. Characters of manganeſe.

THE regulus of manganeſe is a ſemi-metal of dull whitiſh colour when broken, but ſoo grows dark by calcination from the action of the ai It is hard, brittle, though not pulverable, and roug in its fracture; ſo difficultly fuſible, that no heat y exhibited has cauſed it to run into maſſes of any con ſiderable magnitude; and appears to be more diſpoſe to calcination than any other metallic ſubſtance, un leſs we may except wolfram. Its calces are white whe imperfect; but black, or dark green, when perfec the white are ſoluble in acids. When broken pieces, it falls into a powder by ſpontaneous calcin tion; and this powder is magnetic, though the maſſ were not poſſeſſed of that property. It ſeems as the regulus of manganeſe were capable of depriv a ſmall proportion of iron of its magnetiſm; but th the effect ceaſes as ſoon as that regulus is convert into calx. A ſtrong heat expels vital air from t calx of manganeſe.

Concentrated vitriolic acid attacks the regulus manganeſe, but much more readily when diluted w two or three times its weight of water; at the ſa time that inflammable air is diſengaged. A bla ſpongy ſubſtance remains undiſſolved, which has n been examined. The ſolution is colourleſs, and affo cryſt

Black calx of manganeſe.

Theory.

ls by evaporation. Mild alkalis precipitate a calx, ſoluble in acids; but pure alkalis afford a ı calx, which ſoon grows black in the air, and is ly ſoluble. The black calx of manganeſe, when r well made, is altogether inſoluble in acids, ſome combuſtible ſubſtance be added. It ap- therefore that the metal in this ſtate is too far ed, and requires to be reduced again in a certain towards the metallic ſtate, to be diſſolved. If ic acid be added, and drawn off by diſtillation l times from the black calx, by an heat nearly aching to ignition, in a glaſs veſſel; it is found ital air is diſengaged towards the end of each s, and part of the calx is diſſolved. The ſolu- f the calx in acids, by the addition of com- le matter, is eaſily accounted for, on either of eories of chemiſtry, by affirming that the reduc- effected by the addition of phlogiſton, or the ction of vital air from the calx by means of the ſtible ſubſtance. The phlogiſtic theory ap- however to be deficient, in explaining the ſolu- y mere vitriolic acid, at an elevated tempera- on account of the abſence of phlogiſton; but w theory ſimply aſſerts the facts, that the calx ital air in conſequence of the elevated tempe- , and is rendered ſoluble in the acid.

rgman, ii. 215 (on the hypotheſis, that heat is matter; that tter conſiſts of pure air united to phlogiſton; and that eſe decompoſes the heat), derives the phlogiſton required ſolution, as well as the vital air which flies off, from compoſition. Theſe poſitions did not appear ſufficiently d to enter the text.

Solution of regulus of manganeſe in nitrous acid:

Nitrous acid diſſolves the regulus of mangan
with efferveſcence, and the eſcape of nitrous air.
ſpongy, black, and friable matter remains, wh
properties reſemble molybdena. The ſolution d
not afford cryſtals. The perfect calx is not ſolu
in pale nitrous acid, unleſs ſome combuſtible ma
be added.

— in marine acid.

The regulus is diſſolved in the uſual manner
marine acid. The black calx is likewiſe ſolu
but adheres ſo weakly to the acid, as to be ſ
rated even by the mere addition of water: bu
this ſolution be expoſed to a digeſting heat for
hours, an inteſtine motion, like an efferveſc
takes place; the ſmell of dephlogiſticated or aë
acid is perceived; and the combination bec
more perfect, ſo as not to afford a precipitate,
leſs an alkali be added. Marine acid diſſolve
black calx alſo, by the addition of a combu
ſubſtance. Mercury, and even gold, will effect
combination. The ſolution of manganeſe in m
acid ſcarcely affords cryſtals, but a deliqu
ſaline maſs by evaporation, which is ſoluble in
ſpirit.

Explanation.

Page 176—180.

In the permanent ſolution of black calx of m
neſe by marine acid, it is ſeen that the acid
muſt communicate the property to the calx, on
its ſolubility depends; that is to ſay, it muſt
afford phlogiſton, or abſorb vital air: and a
ingly, the red vapours which eſcape are diſting
by the name of dephlogiſticated, or aërated,
acid, according to the theory which may be a
by the ſpeaker.

ıer acids likewiſe diſſolve this metallic ſubſtance.
luor acid, and alſo the phoſphoric acid, form
ounds of difficult ſolubility, which envelope and
l it from their farther action in a ſhort time.

Combinations of calx of manganeſe in the dry way.

the dry way, the calx of manganeſe combines
ſuch earths and ſaline ſubſtances as are capable
lergoing fuſion in a ſtrong heat. Theſe expe-
ts are moſt advantageouſly performed by the
ipe, on ſmall quantities of matter; becauſe,
way, the whole of the phenomena are clearly
The moſt remarkable property of the ſolutions
t a due proportion of combuſtible matter renders
colourleſs; for which reaſon, the calx of man-
is uſed by the glaſs manufacturers, to deſtroy
lours of glaſs. If a globule of microcoſmic
fuſed by the blow-pipe upon charcoal, and
ll portion of the black calx of manganeſe be
the colour will be of a blueiſh red; or
eep red, if the quantity of calx be greater. If
ſion be continued by the interior blue flame,
lour at length diſappears; but may be eaſily
again, by ſoftening the globule with the ex-
flame. A ſmall particle of nitre inſtantly re-
the red colour; but inflammable matter, or
c ſalts, contribute to diſcharge it. If the glo-
fter being deprived of all colour, be fuſed in
er ſpoon, it recovers its redneſs; and the colour
liſcharged by any management of the fuſion,
ſome inflammable matter be added.

Page 209.

Page 44.

Changes of colour.

Explanation.

e remarkable changes of colour, which may be
dly produced, depend evidently on the preſence
nce of combuſtible matter; or, which amounts

MANGANESE.

Explanation of the changes of colour in glaſſes which contain manganeſe.

to the ſame thing, on the degree of calcination of t manganeſe which is held in ſolution. When th highly calcined or black manganeſe is firſt added, produces a coloured globule; if inflammable matt be added, the calx is partly reduced, and forms a c lourleſs combination. Nitre reſtores the colour by i well-known property of calcining metals. When t fuſion is performed by the interior flame, the glob may be conſidered as if heated in a cloſe veſſel, contact with charcoal; becauſe the ſurrounding fla prevents the acceſs of air: a revival of the calx the fore enſues, and the colour vaniſhes. But when external flame is uſed, its apex, or point only, touc the globule; and the ſurrounding air promotes maintains the calcination more effectually than charcoal can produce the contrary effect: the co quence therefore is, that the colour again appe Vitriolic ſalts ſeem to forward the action of the ch coal, which converts them into ſulphur; and colour remains fixed in the ſpoon, becauſe there i combuſtible ſubſtance preſent, which is ſufficientl to promote the revival of the calx. It is evident both the theories of chemiſtry are applicable to t facts, whether the charcoal revives the calx by p giſticating it, or by depriving it of its vital or whether the calcination by the apex of the fl be effected by the diſſipation of phlogiſton, or by abſorption of vital air from the atmoſphere.

Theories.

Nearly ſimilar changes are produced when the is fuſed with borax, or an alkali.

Combination with ſulphur.

Regulus of manganeſe does not appear to com with ſulphur; but eight parts of the calx com

MANGANESE.

ith three of ſulphur, and produce a yellowiſh green aſs, which is acted upon by acids; the metal being iſſolved with effervefcence, and the diſengagement of epatic air. The remaining ſulphur may be collected n a filter.

Metallic combinations of manganeſe.

This ſemi-metal melts readily with moſt of the ther metals, but rejects mercury. Gold and iron re rendered more fuſible by a due addition of manga-eſe; and the latter metal is rendered more ductile. opper becomes leſs fuſible, and is rendered whiter, ut of a colour ſubject to tarniſh *.

Native manganeſe and its ores.

Regulus of manganeſe has been found native among he powdery or calciform ore of this metallic ſub-ance. Its properties, in this ſtate, perfectly reſem-le the regulus produced by art. Manganeſe ap-ears to exiſt in the calcined ſtate in all its ores; ough contaminated with admixtures of earths, or ther metallic matters. They are, white, red, brown, r black; either pulverulent, indurated, or cryſtal-zed. Vegetable aſhes likewiſe afford indications of anganeſe.

Humid analyſis.

To analyſe the ores of manganeſe in the humid ay, they muſt be reduced to a ſubtile powder, and nmerſed in a mineral acid, with a piece of ſugar affiſt the ſolution. If nitrous acid be repeatedly ſtracted to ignition from the ore, the iron it con-ins will be rendered nearly inſoluble from calcina-on; and the manganeſe may be taken up by ſtrong ncentrated vinegar, or diluted nitrous acid. This, hen precipitated by mild mineral alkali, affords 180

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* Annales de Chimie, i. 303.

grains of precipitate for every 100 grains of regulus: or if the metals be precipitated from ſuperabundant nitrous acid, by Pruſſian alkali, the manganeſe will be totally diſſolved by pure water, while the iron remains behind.

Spontaneous inflammation of black wadd.

The ore of manganeſe, which is known in Derbyſhire by the name of black wadd, is remarkable for its ſpontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterwards ſuffered to cool for about an hour; and it be then looſely mixed or kneaded with two ounces of linſeed oil; the whole, in ſomething more than half an hour, becomes gradually hot, and at length burſts into flame. This effect wants explanation. It ſeems, in ſome meaſure, to reſemble the inflammation of oils by the nitrous acid.

Page 165.

Reduction of manganeſe.

The preſence of manganeſe may be aſcertained in the dry way, by the blow-pipe, from the ſingular changes of colour already deſcribed, when fuſed with microcoſmic ſalt, or borax. The reduction of the ore is effected by mixing it with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal, one tenth of an inch thick at the ſides, and one quarter of an inch thick at the bottom then filling the empty ſpaces with powdered charcoal and luting on a cover. This muſt be expoſed to the ſtrongeſt heat of a forge, or furnace, for an hour or more. As the calx of manganeſe is ſtrongly diſpoſed to vitrification, fluxes rather impede than forward the reduction. The reduced globules of man-

ganeſ

Speedy calcination.

ſe are uſually enveloped with a vitrified cruſt, h either partly, or completely, defends them from action of the air; but, when they are broken, loſe their metallic brilliancy and conſiſtence in a ſhort ſpace of time.

Uſes of manganeſe.

Page 176.

anganeſe has hitherto been uſed chiefly by glaſs- rs and potters; but the important diſcoveries of uſes of dephlogiſticated or aërated marine acid no doubt, extend its utility to ſeveral other ma- ctories *.

On manganeſe, conſult Scheele, 67—142; Bergman, ii. 225; the Memoirs of Pelletier, Berthollet, &c.; and the cts by Elementary Writers on Mineralogy.

CHAP. XVI.

CONCERNING WOLFRAM.

WOLFRAM. Page 216.

TUNGSTEN and wolfram have already be treated of in the ſection on acids; and t combinations of metals with the regulus of wolfr have been occaſionally mentioned under their reſp tive heads. Little elſe remains therefore to be of this metallic ſubſtance, than to ſpecify its gen characters.

Characters and habitudes of the calx and regulus of wolfram.

The yellow matter, or calx of wolfram, turns b by expoſure to light; and more intenſely, if to light of the ſun. By a ſtrong heat in a covered cible, it becomes of a blueiſh black colour, with of weight; which it recovers, together with its o nal yellow colour, by calcination, with acceſs of Theſe changes to the blue colour appear there to be partial reductions *. One hundred grai the yellow calx, or acid, being put into a cru with charcoal powder, well covered, and expoſ a ſtrong heat, became converted into a button dark brown colour, and friable, with a diminutio forty grains of the original weight. Its ſpecific vity was 17.6; and, upon examination with a a congeries of metallic globules was ſeen, for them of the ſize of a pin's head; which, when b exhibited a fracture reſembling ſteel. Part of thi

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* De Luyarts on Wolfram, page 58.

WOLFRAM.
Habitudes:

ing calcined, became yellow as at firſt, and gained enty-four per cent. in weight. It was not ſoluble vitriolic or marine acid; but the nitrous acid, and ua regia, converted it again into the yellow calx. he yellow calx itſelf could not be vitrified. Acetous id converted the yellow colour to a blue.

—with ſulphur.

When equal parts of ſulphur and the yellow calx ere urged by a ſtrong heat, a blue friable maſs re-ained, weighing leſs than one-fourth of the whole.

CHAP.

CHAP. XVII.

CONCERNING MOLYBDENA.

MOLYBDENA.
Characters of regulus of molybdena.

MOLYBDENA, like manganeſe and wolfram, has not been reduced into maſſes of any conſiderable magnitude; but has been obtained only in ſmall ſeparate globules, in a blackiſh brilliant maſs. It has been revived by a proceſs ſimilar to that b which regulus of manganeſe is obtained; but it requires a moſt extreme degree of heat for that purpoſe The globules are grey, brittle, and extremely infuſible By heat it is converted into a white calx, which riſe in brilliant needle-formed flowers, like thoſe of antimony. Nitrous acid readily calcines and acidifies th regulus. Nitre detonates with it, and the remainin alkali combines with its calx.

Habitudes with various ſubſtances.
See alſo p. 215.

Detonation with nitre decompoſes the native molybdena; but ſolution in nitrous acid is the readie way to procure the acid of this ſubſtance. Pruſſia alkali, and alſo infuſion of galls, precipitate the aci from its ſolutions. When acid of arſenic is heate with molybdena, it converts part of the ſulphur in volatile vitriolic acid; which comes over, and combines with another portion, with which it riſes the form of orpiment. No other acids but the nitrous and arſenical have any action on crude molybdena.

T

MOLYBDENA.

The regulus of molybdena unites with ſeveral of metals, and forms brittle or friable compounds.

Diſtinctive characters.

This mineral is ſcarce. It is diſtinguiſhable from ck lead by its more ſhining ſcaly appearance, and rks paper with a more brilliant ſtroke; and, as it embles no other ſubſtance, it does not require to aſſayed.

CHAP. XVIII.

CONCERNING URANITE, OR URANIUM.

Uranite, or uranium.

THE celebrated profeſſor Klaproth has detected a new metallic ſubſtance in the mineral uſually diſtinguiſhed by the name of pech-blende, or pitch blende, and ranged among the ores of zinc. As it i not reducible but with the moſt extreme difficulty and then only into minute grains, it appears of littl conſequence to enter into any formal deſcription o its metallic ſtate: for which reaſon, I ſhall follo the order of the profeſſor's analyſis in the preſe chapter *.

Deſcription of pitch-blende.

The pitch-blende, or ore of uranite, is found i maſſes, or elſe ſtratified with other earths or minera in the Swediſh and Saxon mines. It conſiſts of tw varieties: the firſt in maſſes of a blackiſh colour, i clining to a deep ſteel grey, of little brilliancy; fracture is unequal and concave in the ſmalleſt par It is perfectly opake, conſiderably hard, and becom convertible into a black powder by trituration. mean ſpecific gravity is about 7.5. The ſecond riety is uſually found in ſtrata, and is diſtinguiſh from the former by a deeper black colour, intermi with ſpots of red; its colour is more ſhining,

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[*] Journal de Phyſique, April 1790.

approa

ıches that of coal; it is leſs hard, and, when
:ized, it has a greeniſh tinge.

Habitudes by fire.

s mineral ſuffers no change before the blow-
With mineral alkali it affords a ſpongy, ſemi-
, grey globule. With microcoſmic ſalt it melts,
fords a green tranſparent globule; and in both
are ſometimes ſeen ſmall globules of reduced
When the mineral is heated alone, in a proper
it gives out ſulphureous acid and ſulphur, with
weight; but if be afterwards kept ignited for
ſiderable time beneath a muffle, it gains ſome
by calcination.

Action of acids on pitch-blende.

vitriolic acid acts very imperfectly upon pitch-
; but nitrous acid completely decompoſes it,
moſt part in ſolution, while a ſmall propor-
ſulphur, and ſome ſiliceous earth, fall down.
acid acts but imperfectly upon it; but aqua
liſſolves it, as well as the pure nitrous acid.
lution, after it had depoſited a ſmall quantity
ıeous lead, afforded large tranſparent cryſtals
ſe in the cold, which were of a faint yellowiſh
:olour, and of a figure not eaſy to be aſcer-

Precipitates.

as remarkable, that this ſubſtance was not
able from its ſolvents either by iron or zinc;
ıtile liver of ſulphur threw down a browniſh
precipitate. Nut-galls did not precipitate any
ınleſs the ſuperabundant acid were neutralized
lkali; and, in this caſe, the precipitate by galls
a chocolate brown.

Precipitates.

ſtinctive criterion of this metallic ſubſtance
browniſh red colour when ſeparated by Pruſ-

ſian alkali; a circumſtance indeed common al to copper: but this laſt metal falls down in floc whereas the former is uniformly ſeparated throu the whole fluid. Volatile alkali uſually precipita it of a yellow colour, more or leſs obſcure, accordi to the purity of the mineral, or of the alkali. T two fixed alkalis, when pure, precipitate it complet in the form of a lemon-coloured calx. Mild alka afford a paler calx.

Yellow calx of pitch-blende.

The yellow precipitate is very ſoluble in aci and affords cryſtals by combination with the vitri and acetous acids. Phoſphoric acid affords yellow irregular flocks, ſparingly ſoluble in water. Alk do not diſſolve the yellow matter either in the or humid way.

Reduction.

Various attempts were made by the diſcovere revive it to the reguline ſtate. He triturated it linſeed oil to the conſiſtence of a paſte, burned oil in a roaſting teſt, then placed the remai black powder in a crucible lined with charcoal, well covered, and expoſed it to a violent heat; w operated a reduction of manganeſe in another cible, but produced no other change in the cal uranite than to render it ſoluble in nitrous with effervеſcence, heat, and eſcape of nitrous This altered calx was then put into an aſſayer's covered with borax, and mixed with charcoal, the lid luted on. The heat of a porcelain fu reduced it into a coherent maſs, conſiſting of ſmall metallic globules agglutinated together.

BOOK II.

ARTICULAR CHEMISTRY.

SECTION IV.

MINERAL COMBUSTIBLE BODIES, AND THE DIAMOND.

CHAP. I.

OF MINERAL COMBUSTIBLE BODIES.

MINERAL COMBUSTIBLES.

Enumeration.

HE inflammable ſubſtances found in the mineral
kingdom are—1. Inflammable air, called fire-
p in the mines. 2. Hepatic air, which abounds
ıany hot baths, in mines, and in the neighbour-
d of volcanos. 3. Naptha; a fine thin, fragrant,
urleſs oil, which iſſues out of white, yellow, or
k clays in Perſia and Media. This is highly in-
mable, and is not decompoſed by diſtillation. It
lves reſins, and the eſſential oils of thyme and
nder; but is not itſelf ſoluble either in ſpirit of

wine or æther. It is the lighteſt of all the denſe
fluids; its ſpecific gravity being 0.708. 4. Petro-
Petroleum. leum, which is a yellow, reddiſh, brown, greeniſh,
or blackiſh oil, found dropping from rocks, or iſſuing
from the earth, in the duchy of Modena, and in
various other parts of Europe and Aſia. This like-
wiſe is inſoluble in ſpirit of wine; and ſeems to con
ſiſt of naptha, thickened by expoſure to the atmo
ſphere. It contains a portion of the acid of amber
Barbadoes tar. 5. Barbadoes tar, which is a viſcid, brown, or blac
inflammable ſubſtance, inſoluble in ſpirit of wine, an
containing the acid of amber. This appears to b
Aſphaltum. the mineral oil in its third ſtage of alteration. 6. A
phaltum is a ſmooth, hard, brittle, inflammable ſu
ſtance, which melts eaſily, and burns without leavi
any aſhes, if it be pure. It is ſlightly and partia
Mineral tallow. acted on by ſpirit of wine and æther. 7. Mine
tallow, which is a white ſubſtance of the conſiſten
of tallow; and as greaſy, though more brittle.
was found in the ſea on the coaſts of Finland,
the year 1736; and is alſo met with in ſome roc
parts of Perſia. It is near one fifth lighter than t
low; burns with a blue flame and a ſmell of gre
leaving a black viſcid matter behind, which is n
Jet. difficultly conſumed. 8. Jet, which is much har
than aſphaltum; ſuſceptible of a good poliſh,
glaſſy in its fracture. It is highly electrical, fuſibl
a moderate heat, and inſoluble in ſpirit of w
Pit coal. 9. Pit coal. Of this there are many varieties:
appear to conſiſt of petroleum, conſolidated with
Peat. earth, chiefly of the argillaceous kind. 10. Peat
black inflammable earth, which is of a viſcid con

ce when freſh, but hardens by expoſure to the air.

. Turf conſiſts of mould, interwoven with the roots vegetables. 12. Amber has been already treated (198). It is inſoluble in water, and in ſpirit of ne; and no other acid but the vitriolic diſſolves it. diſtillation it affords a ſmall portion of water, an of the nature of petroleum, and a peculiar acid.

. Sulphur is very abundant in the mineral kingdom. has before paſſed under our obſervation, on account its affording the vitriolic acid by combuſtion.

. Plumbago, or black lead.

MINERAL COMBUSTIBLES.

Turf. Amber.

Sulphur.

Plumbago.

When we attend to the inflammable ſubſtances nd in the earth, or in the mineral kingdom, we y perceive that very few, and moſt probably none them, can be truly ſaid to belong to it; but have n elaborated in the bodies of animals or vegeta- s. From the turf that is pared from the ſurface the earth, and owes its inflammability to the roots vegetables which are mixed with it, we may de- nd to the peat, or black earth, of the moors; in ny ſpecimens of which, vegetable remains are perceptible; though in moſt they appear to be rived of every appearance of their organic texture, ir oily and inflammable nature only remaining; from thence the tranſition to pit-coal is eaſy, if we reflect on the vaſt revolutions which the h has certainly undergone through a long courſe ages, by means of which its ſurface has been ken, diſplaced, and inverted, from the actions of ds, earthquakes, and the great convulſions of na- cauſed by volcanic eruptions, it will be no im- bable inference, that the thin, though extenſive,

General obſervations on the combuſtible ſubſtances found in the mineral kingdom.

General obſervations on the combuſtible matter found in the mineral kingdom.

ſtrata of pit coal, as well as the exſudations of naptha, petroleum, and their modifications, have all ariſen from the burying of extenſive woody tracts of the ſurface, ſuch as are common in all uncultivated countries. And this probability will be reduced to a certainty, when we advert to the natural hiſtory of pit coal, which is met with in all the various ſtates of transformation. Whole trees are converted into pit coal, in ſuch quantities together as to exhibit entire foreſts; in which the roots, trunks, branches, bark, and even ſpecies, are diſcernible. Coal-pits and ſlate-quarries exhibit innumerable marks of impreſſions of leaves, and other indications of their vegetable origin; and the analyſis of this combuſtible ſubſtance tends ſtill further to confirm this truth. On the other hand, if we attend to ſuch inferences as chemical theory might point out from the facts around us, we ſhall ſee how ſmall the probability is, that the mineral kingdom ſhould, after a certain limited time, contain inflammable bodies, if they were not occaſionall thrown into it, in conſequence of the operations carried on within organized ſubſtances. For all inflammable ſubſtances, tending to decompoſe the vital air o the atmoſphere, would, in proceſs of time, revert t the claſs of uninflammable bodies, if the operation o organized bodies, particularly of the vegetable kind did not tend to diſengage the vital air again, an render bodies combuſtible, which were not ſo whe they became parts of thoſe ſubſtances.

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CHAP. II.

CONCERNING THE DIAMOND.

DIAMOND.

Characters, &c. of the diamond.

HE diamond is a mineral which, on ſeveral accounts, appears worthy to compoſe an order itſelf. It is found in a ſandy earth in the hither inſula of India, in the iſland of Borneo, and in the izils. The form of the diamond, when perfect, is t of an eight-ſided priſm. There are alſo cubical monds, which are ſuſpected to be of a different ure from the others. Diamonds are of a lamellated ure; and may be eaſily ſplit by a blow in a proper ction. The conſent of mankind has fixed an nenſe value upon this ſtone *. The inimitable qualities

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The value of diamonds is reckoned by weight, at ſo much arat. The carat uſed in this valuation is divided into four , called grains; but leſs than troy grains by one fifth: 150 carats are equal to the troy ounce of 480 grains. gh diamonds, without any flaw or blemiſh, are valued at pounds ſterling the ſingle carat; and the expence of ng amounts to 3¾ pounds the carat. The value is greatly iiſhed if the diamond be imperfect, or of a bad figure; it increaſes rapidly with the ſize. To find the worth rough diamond, its weight in carats muſt be ſquared, and plied by two, and the product will be pounds ſterling. t or finiſhed diamond is worth four times as much as hat is ſtill rough. Thoſe of the greateſt brilliancy are imes valued at a higher rate; but this value has never been d to ſtones of exceſſive magnitude. It does not appear that

DIAMOND.

Hardneſs and brilliance of diamonds:

qualities to which this preference is attached, are its hardneſs, which is ſuch that it eaſily cuts all other ſubſtances, and takes a moſt exquiſite and laſting poliſh; and its very great refracting power, which is ſuch as to occaſion all the light to be reflected, which falls on any of its interior ſurfaces at a greater angle of incidence than 24¼ degrees. Hence its luſtre, when cut into the form of a regular ſolid, is very great. This may be eaſily underſtood, when it is conſidered that an artificial gem of glaſs does not reflect the light from its hinder ſurface, until that ſurface is inclined in an angle of 41 degrees. The diamond therefore will not only throw back all the light which an artificial gem would reflect, but likewiſe one half as much more; which, falling between the angles of 41 deg. and 24¼, would have been ſuffered to paſs through by the falſe gem. It is not ſurpriſing therefore that the effect of the diamond ſhould be ſo much greater; more eſpecially, when we attend to its extreme tranſparency, and the accuracy of its poliſh.

— ſoluble in vitriolic acid:

No ſolvent but the vitriolic acid has any effect on this gem; in which, if diamond powder be triturated, and evaporation carried on nearly to dryneſs, the acid grows black, and depoſits pellicles that burn, and are entirely conſumed. In a heat ſomewha greater than is required to melt ſilver, the diamond is entirely volatilized, and conſumed with a ſligh

— combuſtible.

that any ſum exceeding one hundred and fifty thouſand pound has been given for a diamond.

See Magellan's improved edition of Cronſtedt's Mineralogy for a conſiderable maſs of entertaining information on th ſubject.

flame; diminiſhing common air, and leaving a ſoot behind.

Coloured diamonds.

Diamonds are of all colours: the clear tranſparent ſtones are the moſt eſteemed; and, next to them, thoſe of a deeper tinge. Whether theſe coloured ſtones be really of the ſame nature as the clear diamond, has not been aſcertained. The lapidaries reckon them to be diamonds from their hardneſs and luſtre.

BOOK II.

RTICULAR CHEMISTRY.

SECTION V.

NCERNING THE PRODUCTS OF THE VEGETABLE KINGDOM.

CHAP. I.

THE STRUCTURE AND COMPONENT PARTS OF ORGANIZED SUBSTANCES.

ORGANIZED SUBSTANCES.

General obſervations.

VARIETY of changes takes place among the
great maſs of minerals which come under our
ation near the ſurface of the earth. Theſe,
lered individually, appear to be effected chiefly
tue of the chemical attractions or affinities, aſſiſt-
thoſe variations of poſition and of temperature
ariſe from external cauſes; ſuch as the ſolar
or the alterations which the capacities of other
undergo. But in vegetables and animals there

The parts of organized bodies conſtitute apparatus for performing chemical operations.

is an expreſs organization of parts, which evidently appears to have been deſigned by the Supreme Intelligence for the purpoſe of uniting the powers of mechaniſm to thoſe of chemiſtry. It does not immediately coincide with our preſent intention, to take any notice of ſuch effects as are produced by the muſcular exertion of animals, or any part of their ſtructure, except ſo far as they modify the chemical proceſſes carried on within them. In this point of view, we may conſider the ſolid or conſiſtent parts of vegetables and animals as compoſing an apparatus for performing a number of chemical proceſſes with the fluids that circulate through them. It is true indeed that this whole ſeries of operations is, for the moſt part, performed with ſuch a minute ſet of veſſels; at the ſame time that the bodies applied to each other, to exerciſe their reſpective chemical attractions, ſeem in general to be reduced ſo nea their firſt principles; that in the preſent ſtate of ou knowledge we can ſcarcely proceed farther than t aſſert, that the effects are really produced by an appli cation of the moſt ſublime chemiſtry: but theſe difficulties ought rather to encourage than depreſs ou attempts to arrive at a more intimate knowledge the powers of nature.

Vegetable bodies.

The organs of vegetables appear to conſiſt chie of tubes, adapted to imbibe fluid matter from th earth. This fluid, which is moſtly water, riſes eith by the capillary attraction, by the alternate expanſio and contractions which depend on temperature, by other means; and depoſits its impregnations du ing its tranſition through the veſſels of the pla

T

ction of the ſolar light, the agitation produced
nds, and the nature of the circumambient air,
f great importance in theſe proceſſes. It is Vegetable bodies.
n that vegetables do not thrive in vital air;
hey abſorb fixed air; and that they emit vital
uring the action of light, more eſpecially the
light of the ſun. That they emit plentiful
tions of various kinds, is obvious from their
from the humidity of countries abounding
woods; as well as from the conſideration of
ort time that would be required to dry the
of vegetables, if they did not conſtantly receive
ly of moiſture to recruit what they muſt loſe
nſtant evaporation. We ſee therefore that
are aſſemblages of veſſels, in which water and
fluids are received; and by ſucceſſive mixtures,
ons, evaporations, or depoſitions, are either de-
ſed, or form new compounds. Thus it may
om the decompoſition of water itſelf, that they Page 95.
ital air; while the other principle, or inflam-
air, is retained, and enters into the compoſi-
f their combuſtible parts. Or, if the decom-
n of water be denied, the vital air may ariſe
he abſorption of fixed air; whoſe combuſtible Page 135.
le (whether it be ſuppoſed to be inflammable
ſome philoſophers infer; or charcoal, accord-
others) may be retained, and anſwer a like
e; ſince both theſe ſubſtances are obtained in
lammation of vegetables.

nal bodies are of a much more elaborate ſtruc- Animal bodies.
In theſe there is a proviſion for mechanically
g ſolid bodies by maſtication, which anſwers
the

ORGANIZED SUBSTANCES. the ſame purpoſe as grinding, pounding, or leviga
tion, does in our experiments; namely, that of en
Animal bodies. larging the quantity of ſurface to be acted upon b
ſolvents. The proceſs carried on in the ſtomac
appears to be of the ſame kind as that which w
Page 34. diſtinguiſh by the name of digeſtion; and the bowel
whatever other uſes they may ſerve, evidently forr
an apparatus for filtering, or conveying off, the fluids
while the more ſolid parts of the aliments, which a
probably of ſuch a nature as not to be rendered flui
but by an alteration which would perhaps deſtro
the texture of the machine itſelf, are rejected as uſ
leſs. When this filtered fluid paſſes into the circ
latory veſſels, through which it is driven with con
derable velocity by the mechanical action of the hea
it is not only ſubjected to all thoſe changes whic
the chemical action of its parts is capable of pr
ducing, but is likewiſe expoſed to the air of t
Page 33. 92. atmoſphere in the lungs, into which that elaſtic flu
is repeatedly admitted by the act of reſpiration. He
it undergoes a change of the ſame nature as happe
to other combuſtible bodies when they combine w
its vital part. This vital part becomes condenſed, a
combines with ſome principle emitted from the bloo
at the ſame time that it gives out a large quantity
heat, in conſequence of its own capacity for heat be
diminiſhed. It has not been aſcertained whether
ſubſtance which converts the inſpired vital air i
fixed air (of which a portion is expired from the lu
Page 185. together with the noxious or phlogiſticated air)
inflammable air or charcoal; and it has likewiſe b
doubted whether any part of the vital air is abſor

the blood. Later experiments of Dr. Prieſtley v, however, that this laſt event does actually take e *.

Secretions, or combinations of vegetable and animal ſubſtances.

would lead us too far from our purpoſe, if we e to attempt an explanation of the little we know ecting the manner in which the ſecretions, or binations, that produce the various animal and table ſubſtances, are effected; or the uſes of thoſe tances in the œconomy of plants and animals. t of them are very different from any of the ducts of the mineral kingdom. We ſhall there- only add, that theſe organized beings are ſo rived, that their exiſtence continues, and all their tions are performed, as long as the veſſels are lied with food, or materials, to occupy the place ich as are carried off by evaporation from the ice, or otherwiſe; and as long as no great change ade, either by violence or diſeaſe, in thoſe veſſels, e fluids they contain. But as ſoon as the entire ſs is interrupted in any very conſiderable degree, hemical arrangements become altered; the tem- ure in land animals is changed; the minute s are acted upon, and deſtroyed; life ceaſes; the admirable ſtructure being no longer ſuffi- ly perfect, loſes its figure, and returns, by new inations and decompoſitions, to the general maſs organized matter, with a rapidity which is uſually er, the more elaborate its conſtruction.

Nutrition.

Diſeaſe.

Death.

e parts of vegetable or animal ſubſtances may tained, for chemical examination, either by ſim-

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* Phil. Tranſ. lxxx. 106.

ORGANIZED SUBSTANCES.

Various methods of ſeparating the parts of animal or vegetable ſubſtances.

ple preſſure, which empties the veſſels of their co tents; by digeſtion in water, or in other flui which diſſolve certain parts, and often change th nature; by deſtructive diſtillation, in which the app cation of a ſtrong heat alters the combination of t parts, and cauſes the new products to paſs over i the receiver, in the order of their volatility; by ſp taneous decompoſition, or fermentation, wherein t component parts take a new arrangement, and fo compounds, which did not, for the moſt part, exiſt the organized ſubſtance; or, laſtly, the judicious c miſt will avail himſelf of all theſe ſeveral meth ſingly, or in combination. He will, according circumſtances, ſeparate the parts of an animal or getable ſubſtance by preſſure, aſſiſted by heat; o digeſtion, or boiling in various fluids added in retort, which contains the ſubſtance under exam tion. He will attend particularly to the prod which paſs over; whether they be permanently tic, or ſubject to condenſation in the temperature are able to produce. In ſome caſes, he will the ſpontaneous decompoſition to precede the a cation of chemical methods; and in others he attentively mark the changes which the produ his operations undergo in the courſe of time, ther in cloſed veſſels, or expoſed to the open Thus it is that, in ſurveying the ample field o ture, the philoſophical chemiſt poſſeſſes num means of making diſcoveries, if applied with ment and ſagacity; though the progreſs of diſc ſo far from bringing us nearer the end of our p appears continually to open new ſcenes; and, h

l

ing our powers of inveſtigation, never fails to point additional objects of enquiry.

ORGANIZED SUBSTANCES.

Vegetable products arranged.

treating of the products of the vegetable king-, we ſhall attend rather to the proceſſes by which btain them, than to any arrangement ſuppoſed to among their principles. In this way, the order conſiſt, firſt of principles not ſaline, obtained in gree of heat not exceeding that of boiling water; ndly, ſaline principles, obtained by preſſure, or ſolution in water, or ardent ſpirit; thirdly, ſaline ciples, obtained by ſtrong heat, or by the action itrous acid; fourthly, the products of deſtructive lation; and, laſtly, the products of ſpontaneous mpoſition, or fermentation.

CHAP.

CHAP. II.

CONCERNING SUCH PRINCIPLES OF VEGETABLES DO NOT EXHIBIT SALINE PROPERTIES, AND ARE OBTAINED WITHOUT THE APPLICATION OF ANY GREATER HEAT THAN THAT OF BOILING WATER, AND WITHOUT THE ACTION OF ANY SOLVENT BUT WATER, OR ARDENT SPIRIT.

VEGETABLE PRINCIPLES.

Juices and extracts.

THOSE immediate principles of vegetables, w
do not evidently exhibit ſaline properties,
called juices, when they flow out of inciſions m
in the living plant, or are obtained by ſimple preſſ
and extracts, when rendered thick by evapora
of part of the water they contain. The juice

Purification.

plants are purified by ſuffering their groſſer par
ſubſide, or by filtration. In ſome caſes, the flu
rendered clearer by ſimply heating it in a w
bath, which cauſes part to take the form of a co
lum.

Manipulation.

Dry plants, or woods, or ſeeds, are either ra
pounded, or ground, to ſeparate their parts, and
be macerated, boiled, or digeſted in water, or
of wine; or the inſoluble parts may be ſubject
preſſure, to force out their fluid contents.
fluids may be purified by means ſimilar to thoſe
are applied to the expreſſed juices of plants.

VEGETABLE PRINCIPLES.

Enumeration of ſuch principles of vegetables as are not ſaline.

he principles of plants which are not of a ſaline
re, and are obtained without deſtroying them by
, are—1. Gum, or mucilage, which is ſoluble in
r, but not in ardent ſpirit. 2. Sugar, which is
le both in water and in ardent ſpirit. 3. Starch,
h, though inſoluble in either of theſe fluids, forms
ſte with water, eſpecially if heated. 4. Vegetable
n, which is neither ſoluble nor diffuſible in water
dent ſpirit; has a tenacious conſiſtence when re-
y prepared; but does not imbibe water after it
nce been dried. 5. Fat oils, which are inſoluble
ter or ardent ſpirit, and are either fluid, or fuſible
ut alteration, by a moderate heat. 6. Volatile
ential oils, which are ſoluble in ardent ſpirit, but
water, and riſe totally in diſtillation. 7. Cam-
which differs from eſſential oils in being more
ete, more volatile, and in being totally ſoluble,
ut alteration, in concentrated acids. 8. Reſins,
differ from eſſential oils, in being decompoſable
at; and from camphor, in being changed by
9. The aromatic principle, or vegetable prin-
f ſmell. 10. Colouring matters.

Juices or extracts.

juices or extracts of plants, in general, contain
um and reſin, which may be ſeparated by their
ive ſolvents, water and ardent ſpirit. Theſe
to exiſt together in the plant, forming a com-
of a ſoapy or ſaponaceous nature.

Gum.

is a ſubſtance very well known. It is uſually
rent, more or leſs brittle when dry, and gives
viſcid, and glewy conſiſtence to water in which
ſolved. Gum is uſually obtained by wounding

Mucilage or gum.

the trunks or branches of trees, ſuch as the plum, th
pear, the cherry tree, &c.; and is diſtinguiſhed by va
rious denominations, according to the plant from which
it is obtained. It is obſervable that ſaccharine fruits
when ſour and unripe, are found to contain gum, an
an acid; whence the ſaccharine matter ſeems to b
formed of theſe principles. This is rendered much mor
probable from the conſideration that gum and ſug
afford nearly the ſame products by heat, or by diſtilla
tion with the nitrous acid, as we ſhall hereafter ſhew

Sugar.

Sugar may be reckoned among mucilages or gum
it appears to be brought nearer to the ſaline ſtat
Ardent ſpirit diſſolves it as well as water. The pec
liar taſte of this ſubſtance indicates its preſence in
number of fruits and other vegetables; but it is m
plentifully obtained from the ſugar cane, which
cultivated in warm climates. The juice of the pl
is expreſſed by paſſing it between two cylinders of ir
placed perpendicularly. This fluid, which is th
and tenacious, is boiled together with lime and alu
and is afterwards ſuffered to cryſtallize by ſtanding
a veſſel, in the bottom of which are holes imperfe
ſtopped, in order that the ſyrup may drain off. T
proceſs of refining ſugar appears to be capable of c
ſiderable improvement. It is not clearly aſcertai
what effect the lime and alum have upon the proc
but it is highly probable that a part of the ſuga
burned in the boiling, and converted into an a
which combines with the lime, and would elſe imp
the cryſtallization of the ſugar. The coarſe ſugar
produced, is refined by ſubſequent ſolution in w
and boiling with a ſmall proportion of lime, tog

Manufacture of ſugar.

Manufacture of ſugar.

h bullock's blood or eggs. Theſe fluids, which are
irſt diffuſed through the liquor, have the property of
oming concrete, as the temperature increaſes, and
in the form of ſkum to the ſurface of the fluid,
ying with them the impurities, and rendering it
e clear and tranſparent. The filtered liquor is
either poured into moulds, in which, by a con-
d cryſtallization, it forms loaf ſugar; or elſe it is
ſed in heated rooms, where, by a gradual cryſtal-
ion, it forms ſugar-candy.

he habitude of ſugar with water greatly reſembles
of ſalts; but it has not been aſcertained that it
ains any ſalt ready formed, except a ſmall propor-
of alkali. It is more inflammable than gums.

Flour, or the powder of farinaceous ſeeds.

our, or the pulverized ſubſtance of farinaceous
, has a ſtrong analogy to the gummy and ſaccha-
mucilages. Theſe ſeeds, if moiſtened, and expoſed
moderate or ſummer temperature, become in a
meaſure converted into ſaccharine mucilages, as
ens in the proceſs of converting barley into malt.

Wheat flour waſhed in water.

at flour may be taken as an example of the com-
on of theſe ſeeds, before they begin to vegetate
n. If this be made into a paſte, and waſhed in
ge quantity of water, it is ſeparated into three
ct ſubſtances; a mucilaginous ſaccharine matter,
n is really diſſolved in the liquor, and may be
ated from it by evaporation; ſtarch, which is
nded in the fluid, and ſubſides to the bottom by
; and gluten, which remains in the hand, and is
ious, very ductile, ſomewhat elaſtic, and of a
n grey colour. The firſt of theſe ſubſtances
not eſſentially differ from other ſaccharine muci-

Starch.

lages. The ſecond, namely the ſtarch, forms a glewy fluid by boiling in water, though it is ſcarcely, if at all, acted upon by that fluid, when cold. Its habitudes and products with the fire, or with nitrous acid, are nearly the ſame as thoſe of gum, and of ſugar. It appears to be as much more remote from the ſaline ſtate than gum, as gum is more remote from that ſtate than ſugar.

Vegetable gluten.

The vegetable gluten, though it exiſted before the waſhing in the pulverulent form, and has acquired its tenacity and adheſive qualities from the water it imbibed, is nevertheleſs totally inſoluble in that fluid. It has ſcarcely any taſte. When dry it is ſemi-tranſparent, and reſembles glue in its colour and appearance. If it be drawn out thin, when firſt obtained, it may be dried by expoſure to the air; but, if it be expoſed to warmth and moiſture while wet, it putrefies like an animal ſubſtance. The dried gluten, applied to th flame of a candle, crackles, ſwells, and burns, exactl like a feather or piece of horn. It affords the ſam products by deſtructive diſtillation as animal matter do; is not ſoluble in ardent ſpirit, oils, or ether; an is acted upon by acids and alkalis, when heated.

Fat oils.

Fat oils are obtained by preſſure from the emulſi ſeeds or kernels of vegetables: they are generally flu in the temperature of the atmoſphere, but ſome them have a conſiderable degree of firmneſs or ſolidit They have a very ſmooth feel; are moſtly witho ſmell or taſte; require a degree of heat much ſuperi to that of boiling water, to cauſe them to riſe in eb lition; and cannot be ſet on fire, unleſs heated to t

degr

VEGETABLE PRINCIPLES.

Fat oils:

ree. The uſe of the wick of a lamp conſiſts in nging ſmall portions of oil to its extremity, by the illary attraction, where they become ſucceſſively atilized and inflamed. Oils are remarkably leſs orous than water, when poured out. Fat oils, not ng at all diſſipated by the heat of the atmoſphere, ke a permanent greaſy ſpot when they fall on po- s ſubſtances.

— decompoſed by diſtillation:

hefe oils are decompoſed by diſtillation, and afford nall quantity of water loaded with a peculiar acid, ght oil, a denſe oil, inflammable air, and fixed air. e reſidue conſiſts of a ſmall quantity of charcoal.

— habitudes with air, water, and various ſubſtances.

at oils, by expoſure to the air, become rancid; and ibit a diſengaged acid, which may be waſhed off vater. When they are expoſed to the air, in a coat upon the ſurface of water, they become more iſtent, like wax, by abſorbing the vital part of the oſphere; the aërated or dephlogiſticated marine produces this change more ſpeedily. Agitation water ſeparates a mucilage from them. They bine with magneſia, and with lime, which con- them into ſaponaceous compounds. With the alkalis they form common ſoap. They do not e with the volatile alkali, but by long trituration.

Page 120.

he mineral acids unite with fat oils, and form pounds, or imperfect ſoaps. Fuming nitrous acid s them to take fire, as has already been obſerved. hur is ſoluble in fat oils, by a digeſting heat; and adually depoſited in part from them, in a cryſtal- form, by cooling.

Page 165.

eſe ſulphureous compounds are called balſams lphur.

Bitumens and amber are ſoluble in fat oils, and form varniſhes.

Volatile or eſſential oils :

Volatile or eſſential oils have uſually a ſtrong aromatic ſmell, are ſufficiently volatile to riſe with the heat of boiling water, and are in general ſoluble in ſpirit of wine. They exiſt in almoſt all fragrant ve- getables; and in the various plants they are found either in the wood, the root, the bark, the leaves, the flowers, the fruits, &c. They differ very much in the degree of fluidity they poſſeſs at a common temperature, and their colours are various. They are ob-

— obtained by preſſure or by diſtillation ;

tained either by expreſſion, as from the peel of oranges and lemons, or by diſtillation with water. Some eſſential oils, ſuch as thoſe of cinnamon, ſaſſafras, and other foreign plants, ſink to the bottom oi the water, with which they come over; others floa at the top. It is eaſy to diſtinguiſh the adulteratio of volatile oils, either by pouring ardent ſpirit upo them, which will not diſſolve the fat oil they may b contaminated with; or if they be dropped on paper and held to the fire, in this caſe they leave a greaſ ſpot behind. If oil of turpentine be fraudulentl added to them, its ſmell betrays its preſence whe treated in this manner.

— are inflammable.

Volatile oils are very inflammable. By expoſure t air, they become thick in proceſs of time, and aſſum the character of reſins.

Combinations.

They unite with difficulty to lime and alkalis. Th vitriolic acid converts them into bitumens; but, i diluted, it renders them ſaponaceous, as does likewiſ the muriatic acid. Nitrous acid inflames them.

They unite very readily with ſulphur, and form ba

ſam

ſams. Mucilages and ſugar render them ſoluble or diffuſible in water.

Camphor.

Camphor is a peculiar vegetable ſubſtance, which reſembles volatile oil, and is in fact depoſited from ſome of the volatile oils by long ſtanding. It has been obtained in ſmall quantities by diſtillation with water from thyme, roſemary, ſage, and other fragrant plants. The camphor of commerce is obtained from a ſpecies of laurel, which grows in China and the Indian iſlands, by diſtillation of the wood and other parts of the tree with water. The camphor riſes by the heat, and is afterwards purified by a repetition of the proceſs, with the addition of about one-twelfth of its weight of lime.

Characters of camphor:

This ſubſtance is much more volatile than eſſential oils. It cannot be preſerved without loſs, but in cloſed veſſels, and even in theſe it ſublimes by the heat of ſummer. Water does not diſſolve it; but it is plentifully ſoluble in ſpirit of wine, in ether, and in concentrated acids; from all which it is ſeparated, without alteration, by the addition of water. Fixed and volatile oils diſſolve camphor, with the aſſiſtance of heat, and depoſit cryſtals in the form of a beau ful vegetation by cooling.

— its acid.

A peculiar acid is formed by diſtillation of the ni ous acid from this ſubſtance.

Reſins, how obtained.

Reſins are dried juices of plants, which are of the ature of eſſential oil. They uſually flow from wounds ade in the trunks of trees for that purpoſe. Fragrant ſins have been diſtinguiſhed by the name of balſams. lmoſt all the concrete juices, diſtinguiſhed by the ame of reſins, are ſoluble in ardent ſpirit. Water

diſſolves

diſſolves none of them. They are inflammable, and burn with much ſmoke. In cloſed veſſels they do not riſe wholly by heat, like eſſential oils, but are decompoſed.

Refinous ſubſtances.

A very conſiderable number of reſinous ſubſtances are known and uſed in the arts. Common reſin of the pine, the reſin of the fir, pitch, tar, and turpentine, are among thoſe which are ſoluble in ſpirit of wine, and are of the nature of eſſential oils. Copal, and the elaſtic ſubſtance called caoutchouc, which is the inſpiſſated juice of a tree from Africa, are uſually reckoned among reſins; though neither ſpirit of wine nor water diſſolves them. They are ſoluble however in oils, by the aſſiſtance of heat, and ſeem to be of the nature of fat oils. The juices called gum reſins are variouſly ſoluble in the different menſtruums, according to the nature and abundance of their component parts.

Principle of ſmell in vegetables.

The principle of ſmell in plants appears to be of an exceedingly ſubtile nature. It ſeems in general to reſide in the eſſential oil, and compoſes an extremely ſmall part of the weight of vegetables, as may be inferred from the loſs of fragrance ſuſtained by eſſential oils, with little or no loſs of their weight. This however does not neceſſarily ſuppoſe that the whole principle of ſmell has flown off; becauſe it may with equa probability be ſuppoſed to have entered into combination with ſome of the other principles of the ſubſtanc which afforded it. Diſtillation with ſpirit of wine i uſed to extract the fragrant principle from plants. A conſiderable proportion of this matter may be obtaine by diſtillation with water, in which it comes ove

robably diffuſed with a ſmall proportion of eſſential
il. It has been ſuppoſed to conſiſt of an elaſtic fluid
f a peculiar nature.

Colouring matters:

The knowledge of the colouring matters of vege-
ables is of great importance to ſociety, as the art of
ying depends on the application of theſe ſubſtances.
Iuch however remains to be aſcertained concerning
iem. If the doctrine of Newton were incontro-
ertibly eſtabliſhed, that the colours of bodies depend
olely upon the magnitude of the integrant particles
f bodies, we might aſſert, without heſitation, that
l the principles of bodies might be applied in theory
the production of any aſſignable colour; and we
ight thence infer, that the colour of plants is not
oduced by the diffuſion of coloured particles of any
rticular kind, but by the configuration of the parts
ken in general. But we are not ſufficiently advanced
any part of the knowledge of nature, to reaſon
th ſafety, without conſtant recurrence to the teſt
experiment. In this way we find that the chemical
vents, in many inſtances, deprive plants of their
lour, at the ſame time that they themſelves acquire
; doubtleſs by ſolution of the colouring matter,
iich they again depoſit upon bodies prepared for that
rpoſe. Water diſſolves the colouring matter of va-
us ſubſtances, ſuch as logwood, madder, &c. The
ffs to be dyed require, in many caſes, the previous
king in a ſolution of alum, vegetable alkali, or
ier ſalts, to prevent their giving the colour out
in to water. Other colouring principles are ſolu-
: in oils, ſuch as alkanet; and many which are not
ſoluble

— are taken up by chemical ſolvents.

Art of dying.

ſoluble in water, are taken up by that fluid, by the intervention of an alkali. The art of dying, or of fixing colouring matter upon various ſtuffs, appears to depend upon the chemical affinities of the colouring matters either with the ſtuffs themſelves, or the matters in which they are previouſly infuſed. The condition required in a good dye appears to be, that the colouring matter ſhall be precipitated on the ſtuff, and form a compound not ſoluble in the liquids to which the ſtuff will probably be expoſed. Thus, for example, printed or dyed linens or cottons ought to reſiſt the action of ſoap and alkalis; and woollens ought more particularly to withſtand the action of acids, ſuch as lemons, vinegar, &c. which may accidentally fall on them.

Lakes.

Certain colours, called lakes, are prepared by diſſolving the vegetable colouring matters, and precipitating them by the addition of ſome other ſubſtance. Thus, for example, if madder be boiled in water together with an alkali, and alum be then added, the earth of the alum will be precipitated together with the colouring matter, with which it will form an inſoluble pigment.

CHA

CHAP. III.

ERNING THE SALINE PRINCIPLES OF PLANTS BTAINED BY PRESSURE, OR BY THE APPLICATION OF WATER OR ARDENT SPIRIT; PARTICULARLY THE ACIDS OF LEMONS, OF APPLES, OF NUT-GALLS, AND OF BENZOIN.

VEGETABLE SALTS.

Mineral ſalts found in vegetables.

HE ſaline principles of plants are either ſuch as are found in the mineral kingdom; namely, lated tartar, Glauber's ſalt, nitre, common ſalt, the fixed alkalis; or they are ſuch as are pe- to this kingdom. The mineral ſalts are ſup- to have entered into the veſſels of the plants afford them, and to have remained there un- d.

Peculiar ſalts enumerated.

The ſalts peculiar to vegetables are, for the part, of an acid nature. They conſiſt of the of lemons and of apples, which are obtained in npure ſtate by preſſure; the acid of nut-galls, he acid of benzoin; the ſalts of tartar and of , which contain a portion of alkali; and ſuch as are formed by diſtilling the nitrous acid from able ſubſtances, which are thoſe of ſugar, cam- cork, &c. Deſtructive diſtillation likewiſe de- s or forms peculiar acids. Thoſe obtained from , from mucilage or ſugar, and from wood, have een examined.

The

VEGETABLE ACIDS.

Various methods of preſerving lemon-juice:

The juice of lemons, or limes, has all the charac
ters of an acid of conſiderable ſtrength. On accoun
of the mucilaginous matter with which it is mixed i
its firſt ſtate, it is very ſoon altered by ſpontaneou
decompoſition. Various methods have been contrive
to prevent this effect from taking place, in order tha
this wholeſome and agreeable acid might be preſerve
for uſe in long voyages, or other domeſtic occaſion

— by oil:

The juice may be kept in bottles under a thin ſtratu
of oil, which indeed prevents, or greatly retards, i
total decompoſition; though the original freſh ta
ſoon gives place to one which is much leſs gratefu

— by evaporation:

In the Eaſt Indies it is evaporated to the conſiſten
of a thick extract. If this operation be carefully pe
formed by a very gentle heat, it is found to be ve
effectual. When the juice is thus heated, the muc
lage thickens, and ſeparates in the form of flock
part of which ſubſides, and part riſes to the ſurfac
theſe muſt be taken out. The vapours which ari
are not acid. If the evaporation be not carried
far as to deprive the liquid of its fluidity, it may
long preſerved in well-cloſed bottles; in which, aft
ſome weeks ſtanding, a farther portion of mucila
is ſeparated, without any perceptible change in t
acid.

— by freezing.

Of all the methods of preſerving lemon juice, th
of concentrating it by froſt appears to be the be
though, in the warmer climates, it cannot convenien
be practiſed. Lemon juice, expoſed to the air in
temperature of between 50° and 60°, depoſits in a f
hours a white ſemi-tranſparent mucilaginous matt
which leaves the fluid, after decantation and filtratio

mu

leſs alterable than before. This mucilage is
f a gummy nature, but reſembles the gluten of
t in its properties: It is not ſoluble in water,
dried. More mucilage is ſeparated from le-
juice by ſtanding in cloſed veſſels. If this de-
ed lemon juice be expoſed to a degree of cold
out ſeven or eight degrees below the freezing
, the aqueous part will freeze, and the ice may
ken away as it forms; and if the proceſs be
nued until the ice begins to exhibit ſigns of
y, the remaining acid will be found to be re-
l to about one-eighth of its original quantity,
e ſame time that its acidity will be eight times
enſe; as is proved by its requiring eight times
uantity of alkali to ſaturate an equal portion
This concentrated acid may be kept for uſe;
preferred, it may be made into a dry lemonade,
lding ſix times its weight of fine loaf ſugar in
er [*].

Depuration of the acid of lemons:

—by congelation:

e above proceſſes may be uſed when the acid
mons is wanted for domeſtic purpoſes; becauſe
eave it in poſſeſſion of the oils, or other princi-
on which its flavour peculiarly depends. But in
ical reſearches, where the acid itſelf is required
had in the utmoſt purity, a more elaborate pro-
muſt be uſed. Boiling lemon juice is to be ſatu-
with powdered chalk, whoſe weight is to be
. The neutral ſaline compound is ſcarcely more
le in water than ſelenite: it therefore falls to the
m; while the mucilage remains ſuſpended, in

—by the chemical affinities.

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[*] Georgius, quoted by Fourcroy, iv. 33.

Depuration of acid of lemons.

the watery fluid which muſt be decanted off. The r
maining precipitate muſt then be waſhed with war
water until it comes off clear. To the powder, th
edulcorated, a quantity of vitriolic acid, ſufficient
ſaturate the chalk, and diluted with ten parts of wat
muſt be added, and the mixture boiled a few minute
The vitriolic acid combines with the lime, and forn
ſelenite, which remains behind when the cold liqu
is filtered; while the diſengaged acid of lemons r
mains diſſolved in the fluid. This laſt muſt be ev
porated to the conſiſtence of a thin ſyrup; and vit
olic acid muſt be then added in ſmall portions,
precipitate the lime, if any ſhould ſtill remain
combination with acid of lemons. When no mo
precipitate is afforded by the addition of vitrio
acid, a farther evaporation ſeparates the pure acid
lemons in cryſtals. It is neceſſary that the vitrio
acid laſt added ſhould be rather in exceſs; becau
the preſence of a ſmall quantity of lime will preve
the cryſtallization. This exceſs will be found in t
mother water *.

Characters.

The concrete acid of lemons remains conſiſtent
the air, is very ſoluble in water, and exhibits ſtro
acid properties. Its watery ſolution is decompoſed
a ſlow putrefaction. It unites with the alkalis a
earths, ſilex excepted; and forms peculiar neut
ſalts, which have not yet been much examined. Se
ral of the metallic ſubſtances are likewiſe acted up
by it; and it would probably diſſolve all their calces

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[*] Scheele's Eſſays, Eng. Tranſlation, p. 361; or Crell's J
nal for 1784.

Method of purifying the acid of apples.

he acid which abounds in ſour or unripe fruits
bits diſtinct properties. As it is plentifully ob-
ed from apples, the firſt examiner, Scheele, has
ominated it the acid of apples. In order to obtain
e juice of ſour apples is expreſſed from the fruit,
ſaturated with vegetable alkali. To this liquor
lution of the vitriolic ſalt of lead muſt be very
ually added. A double decompoſition takes place.
vitriolic acid combines with the alkali, and forms
olated tartar; at the ſame time that the acid
pples, uniting with the lead, forms an inſoluble
ipitate. When the precipitate nearly ceaſes to
down, the ſolution of ſugar of lead muſt be
d cautiouſly, by a drop at a time, until no more
ipitate is afforded. The vitriolated tartar may
aſhed off from the precipitate; and diluted vi-
ic acid being then poured on the precipitate, ſugar
ad is again formed, and the acid of apples is ſet
erty.

Separation of the acids of lemons and of apples.

ſuch fruits as contain the acid of lemons as well
at of apples, the ſeparation of one from the other
compliſhed by the following proceſs. The juice
gooſeberries, for example, is evaporated to the
iſtence of ſyrup: pure ardent ſpirit being poured
this, diſſolves the acids, and leaves the muci-
which may be ſeparated by filtration. The
nt ſpirit being then evaporated, and water added,
acids muſt be ſaturated with chalk. The ſolution
g boiled for a few minutes, the calcareous ſalt
mons falls to the bottom, on account of its difficult
ility; while the other ſalt, conſiſting of the acid
pples, united to lime, remains ſuſpended, and may
conſe-

Acid of apples.

conſequently be decanted off. This neutral ſalt no being ſoluble in ſpirit of wine, may be precipitated b the addition of a proper quantity of that fluid; which at the ſame time, deprives it of a portion of ſaponaceous and ſaccharine matter. The coagulum, or precipitate, which conſiſts for the moſt part of the aci of apples, perfectly neutralized by lime, may be diſſolved in boiling water. An addition of ſugar of lea forms a precipitate by double affinity, as in the fir caſe, conſiſting of the acid of apples united to lead and this waſhed precipitate may be decompoſed by th addition of diluted vitriolic acid, which combines wit the lead, and ſets the acid of apples at liberty.

Characters.

This acid exhibits peculiar properties. It canno be obtained in cryſtals; and forms deliqueſcent ſal with the three alkalis, and alſo with magneſia. I ſaline combination with lime is cryſtallizable; an with clay it forms a ſalt of very ſparing ſolubility. I diſſolves iron, with which it forms a ſalt that does no cryſtallize. With zinc, it forms a ſalt which afford beautiful cryſtals. It precipitates the nitrous ſolution of mercury, lead, ſilver, and gold, in the metallic ſtate when nitrous acid is diſtilled from it, it is converte into acid of ſugar.

The aſtringent principle.

Many vegetable ſubſtances, ſuch as the huſks o nuts, the bark of the oak, the nut-gall, and othe vegetable matters, abound with a ſubſtance which ha been diſtinguiſhed by the name of the aſtringent principle. Its diſtinguiſhing character is that of prec pitating iron from its ſolutions in acids, of a blac colour. The nut-gall is chiefly uſed for this, and othe

purpoſ

ſes wherein the application of this property is ed; and, as it reſembles acids in its properties, incipile has been called the acid of galls.

Acid of galls obtained in ſolution:

: acid of galls is obtained by macerating the ll in water. This infuſion reddens turnſole and aper. The acid is ſoluble in oils, ardent ſpirit, ther. Acids diſſolve it, without impairing its ty of forming a black precipitate with the ſolu- f iron: the diſtilled products of nut-galls like- oſſeſs the ſame property. It decompoſes me- olutions, and combines with their calces: gold ver are precipitated by it in the metallic ſtate. upon and diſſolves iron directly.

—in the cryſtallized form.

obtain the acid of nut-galls in a cryſtallized one pound of the powder of galls muſt be added pounds of diſtilled water, and left to digeſt for ight, at the temperature of between 70 and 80 s; after which, the fluid muſt be filtered, and evaporate ſpontaneouſly in the open air, in a vare or glaſs veſſel. The fluid becomes mouldy, vered with a thick glutinous pellicle; abundance inous flocks fall down; and in the courſe of three months the ſides of the veſſel appear l with ſmall yellowiſh cryſtals, which are like- ry abundant at the under ſurface of the pellicle covers the liquor. The fluid muſt then be de- ; and ardent ſpirit, being poured upon the mu- us depoſition, the cryſtals and the pellicle, diſ- he ſalt by the aſſiſtance of heat, without touching cilage; and, by evaporation of this ſpirituous , the pure gallic acid is obtained in ſmall bril- yſtals, of a grey colour inclining to yellow.

Page 300. General characters and habitudes of the acid of galls.

This acid, on account of its long expoſure to th
air, may conſiſt either of a principle exiſting in th
galls, or of that principle converted into an aci
It has the following properties: It precipitates marti
vitriol, and other ſalts of iron, of a beautiful bla
colour, and ſtrongly reddens the tincture of turnſol
when heated, with contact of air, it ſwells up, a
burns, leaving a coal behind of difficult incineratio
by diſtillation, with a gentle heat, part of the ac
comes over diſſolved in the water of cryſtallizatio
another portion ſublimes undecompoſed in the form
ſilky cryſtals; and a ſtrong heat ſeparates a few dro
of oil, with fixed and inflammable air.

The acid of galls is ſoluble in twenty-four parts
cold water, or three of boiling water. It is mu
more ſoluble in ſpirit of wine; four parts of this be
ſufficient at the common temperature, or one wh
boiling hot. With lime, magneſia, or ponder
earth, it forms ſalts which are ſoluble in water:
unites readily with the alkalis, and forms compou
which have not been much attended to. The act
of the nitrous acid converts it into the acid of ſug
This acid precipitates gold, ſilver, mercury, copp
iron, and biſmuth, from their ſolutions; but it d
not affect thoſe of platina, zinc, tin, cobalt,
manganeſe.

Benzoin.

The fragrant reſin, called benzoin, affords a p
liar concrete acid by ſublimation, which is about
tenth of the weight of the reſin itſelf, but varie
different ſpecimens. This acid exiſts ready for
in the benzoin; but cannot eaſily be waſhed ou
w

VEGETABLE ACIDS.

Method of obtaining the acid of benzoin in the humid way.

ter, on account of the reſin which defends it. The
t method of obtaining it, in the humid way, is the
lowing: Lime-water is made by ſlacking four
nces of quick-lime with twelve ounces of water;
l, as ſoon as the ebullition is over, eight pounds
re of water are to be added. Six ounces of this
e-water are to be mixed by agitation with one
und of benzoin in powder, and the whole of the
e-water is then to be added; the mixture being ex-
ed to heat over a gentle fire for half an hour (dur-
which time it muſt be continually agitated, to
vent the powder from coagulating), is afterwards
ered to cool, and ſettle for ſeveral hours. The
r liquor muſt then be decanted, and the reſidue
led for half an hour with eight pounds of water;
ch, after ſubſidence and decantation, muſt be added
the clear fluid of the firſt boiling. The ebullition
he reſidue of the matter muſt be again twice re-
ted, and the decanted lixiviums added to the fore-
g. All theſe waters are then to be evaporated
wo pounds; during which operation a ſmall quan-
of reſin falls down. When the evaporated liquor
ool, a quantity of marine acid muſt be added drop
drop, with conſtant ſtirring, till there be no more
ipitation, or till the maſs has a ſouriſh taſte. The
ipitate is the acid of benzoin.

Rationale.

he rationale of the above proceſs is this: The
unites with the acid of benzoin during the ebul-
n: the evaporation ſeparates a ſmall quantity of
; and diminiſhes the aqueous fluid ſo much, that
he ſubſequent part of the operation the acid of
oin may fall down, and be ſeparated for want of

Method of obtaining the acid of benzoin.

a ſufficient quantity of water to diſſolve it. The marine acid, which is added laſt of all, ſeizes the lime by its ſtronger affinity, and forms a ſoluble ſalt; while the acid of benzoin, which is diſengaged, falls down, on account of its ſparing ſolubility. The acid thus obtained has the form of a very fine powder. If it be required in the form of ſilky threads, it may be diſſolved in boiling water, and ſtrained through a cloth. As cold water diſſolves little more than one five hundredth part of its weight, though boiling water diſſolves about one twentieth of this acid, the greateſt part of the acid ſeparates by cooling.

Its characters.

The acid of benzoin combines with the ſoluble earths and alkalis, and forms compounds, which have been little attended to. It is ſoluble in the vitriolic and nitrous acids; and may be again ſeparated, withou alteration, by the addition of water. Its habitude with theſe acids, particularly the latter, when heated have not been ſatisfactorily aſcertained. If its natur be changed by diſtillation with nitrous acid, it ſeem probable that it is effected with much more difficult than is experienced with other vegetable acids.

CHAP. IV.

NCERNING THE ACIDS OF TARTAR AND OF SORREL.

VEGETABLE ACIDS.

Tartar.

HE two acids which are uſually found in com-
bination with a portion of the vegetable alkali,
the acid of tartar and of wood ſorrel. Tartar
for a long time been conſidered as one of the
ducts of the vinous fermentation; but it exiſts
ly formed in muſt, in verjuice, and is likewiſe
ined in other chemical proceſſes with vegetables.
vever, it is obtained, for all the purpoſes of com-
ce, from wine; during the inſenſible fermentation
which liquid, it is gradually depoſited on the ſides
he caſks.

Cream and cryſtals of tartar.

rude tartar is ſeldom uſed in medicine, or philo-
ical chemiſtry; the refined tartar is known by the
e of cream, or cryſtals, of tartar. The purification
his ſalt is effected by diſſolving it in boiling water,
ring and ſuffering it to cryſtallize by cooling; the
tals are again boiled, together with an argillaceous
h, to deprive them of their impurities, which are
fully ſcummed off; or elſe with whites of eggs,
ch anſwer the ſame purpoſe. When no more
n ariſes, a ſaline pellicle is formed at the top of
liquor, at the ſame time that the cryſtallization
forward at the bottom. This ſalt, after the earth
aſhed off with cold water, is ſold under the name

of cream, and cryſtals of tartar. The cream of tartar conſiſts of the minute cryſtals which are formed at the top of the liquor, and the cryſtals of tartar are formed at the bottom.

Characters of purified tartar.

The taſte of this purified ſalt is leſs vinous than that of the crude tartar. When expoſed to heat, it boils up, emits an epyreumatic ſmell, and becomes black and coaly; a ſtronger heat in an open fire entirely diſſipates its acid part, and leaves the vegetable alkali in a mild ſtate, or combined with fixed air. Its volatile products, by a gradual fire, are water, an acid, and an epyreumatic oil, which is followed by ſome volatile alkali, and a large quantity of fixed air. Cryſtals of tartar are ſoluble in twenty-eight parts of boiling water; three-fourths of the ſalt are depoſited in cooling. If the ſolution of this ſalt be left expoſed to the air, it is very ſlowly decompoſed; mucilage is depoſited, the acid diſappears, and after eighteen months the liquid is found to contain the vegetable alkali, amounting to nearly one-fourth of the weight of the tartar. This quantity of alkali being nearly the ſame as is afforded by the incineration of tartar, is a proof that the vegetable alkali is not a product of fire, as was formerly ſuppoſed.

Habitudes.

The habitudes of tartar with clay and ponderous earth have not been aſcertained. Magneſia forms with it a ſoluble ſalt. Chalk unites with the exceſs of acid in the tartar, and ſeparates the neutral ſalt; conſiſting of the vegetable alkali, ſaturated with the tartareous acid, which is known by the name of ſoluble tartar. If the vegetable alkali be added to a ſolution of cream of tartar, in ſuch a quantity as to ſaturate it, the ſame neutral

Soluble tartar.

Soluble tartar.

ral ſalt, or ſoluble tartar, will be formed. This a bitter taſte, and is decompoſed by heat, affording ſame volatile products as cream of tartar. It is ble in four parts of water heated to 110°, and ds cryſtals which are ſlightly deliqueſcent.

Curious fact.

is a curious fact, though by no means ſingular he hiſtory of neutral ſalts, that two very ſoluble tances, ſuch as the vegetable alkali, and the acid artar, ſhould compoſe a ſalt of ſo little ſolubility he cryſtals of tartar; more eſpecially, as the point the greateſt difficulty of ſolution is not that at ch they are ſaturated, but that in which the acid onſiderably abounds.

Manufacture of Rochelle ſalt.

f to twenty ounces of purified tartar, diſſolved in r pounds of boiling water, the pure cryſtallized eral alkali be added, until the ſaturation be com- e, as may be judged by any additional quantity ducing no effervefcence; the alkali laſt added will nbine with the ſuperfluous acid of the tartar, and m the neutral combination called the ſalt of Seig- te, or Rochelle ſalt; at the ſame time that the reſi- of the tartar will become converted into ſoluble ar. By evaporating the liquor nearly to the con- ence of ſyrup, the Rochelle ſalt is obtained in utiful regular priſms, of ſix or eight ſides, which oreſce in the air, and are decompoſed by heat in ſame manner as ſoluble tartar.

By the ſame treatment with volatile alkali, an am- niacal tartareous ſalt is formed, which affords cryſ- s that effloreſce in the air.

Ammoniacal ſalt of tartar.

If the mineral acids be added to tartar, they com- e with its alkali, and form the ſame ſalts as they would have produced by direct union with the vegetable alkali.

Tartar.

Tartar has long been an object of attention with chemiſts, and it is uſed as an acid in many of the arts. This ſalt appears to be capable of uniting without decompoſition, and forming triple ſalts with moſt of the metals.

Method of obtaining the acid of tartar:

The pure acid of tartar may be obtained by ſaturating three parts of cream of tartar with chalk or lime; the former of which combines with the ſuperfluous acid, and the latter ſeizes the whole. The calcareous tartar, which, on account of its inſolubility, remains at the bottom, is then to be well waſhed, and digeſted with about one part of vitriolic acid, together with a ſufficient quantity of water. In this manner the acid of tartar is diſengaged. The ſelenite formed by the combination of the vitriolic acid and the lime, will be ſeparated, and fall down, by evaporating the water; and the acid which remains may be cryſtallized by further evaporation and cooling.

— or otherwiſe.

Or, more ſimply, one pound of cream of tartar may be boiled in five or ſix pounds of water, and a quarter of a pound of clear and colourleſs denſe vitriolic acid may be added by little and little. When a complete ſolution is obtained, the fluid will then contain diſengaged acid of tartar, together with vitriolated tartar, or the neutral ſalt, formed by the union of the vitriolic acid with the vegetable alkali. The vitriolated tartar, being a ſalt of ſparing ſolubility, will be precipitated by continuing the boiling. When the liquor is evaporated to one half, it is to be filtered; and if, upon further evaporation, any thing more is precipitated,

ed, it muſt be filtered again. The clear liquor
then reduced to the conſiſtence of a ſyrup, and
y in a temperate or rather warm place, will afford
cryſtals of tartareous acid, equal in weight to
the cream of tartar employed. If too ſmall a
tity of vitriolic acid has been uſed, part of the
n of tartar will not be decompoſed, but will
ate from the liquor along with the vitriolated
. It is better therefore to uſe too little rather
too much.

Acid of tartar:

e cryſtallized tartareous acid melts, fumes, be-
s black, and burns, by the contact of ignited
s. By diſtillation it affords an acid phlegm, a
quantity of oil, and much fixed air, together
inflammable air; leaving behind a coaly reſidue,
contains neither acid nor alkali.

—its characters,

e cryſtals of tartareous acid do not change by
ure to air; they are much more ſoluble in water
cream of tartar itſelf. This acid diſſolves clay,
rms a ſalt which, by evaporation, aſſumes a clear
y conſiſtence, and does not deliqueſce in the
The ſame appearance is exhibited with mag-
with lime, it forms a ſalt which is ſcarcely at
uble; a due proportion of vegetable alkali con-
it into cream of tartar, which falls down if the
of ſolution be not ſufficiently abundant, but is
ed again if more alkali be added, ſo as to con-
t into ſoluble tartar. Theſe ſynthetical opera-
ſhew that the tartareous acid is not altered by
oceſs of extracting it from cream of tartar.
th the mineral alkali it forms the Rochelle ſalt,
ith volatile alkali it forms a cryſtallizable ſalt.

and habitudes.

In

In this laſt combination there is a term at whic cryſtals of ſparing ſolubility, like thoſe of cream q tartar, are formed; and in this caſe likewiſe the aci of tartar is far from being ſaturated with the alkali.

This acid is convertible into the ſaccharine acid b diſtillation with ſtrong acid of nitre: and it is co verted into acetous acid by digeſtion with water a ardent ſpirits.

Salt of ſorrel:

Salt of ſorrel is a cryſtallized ſalt; ſo denominat becauſe it is obtained from the wood ſorrel, or oxa aceto-ſella of Linnæus, for the purpoſes of commerc though it may be obtained from ſome other plai It is in white cryſtals, whoſe figure has not been w determined, on account of their minuteneſs. Wh it is expoſed to diſtillation in a retort, the acid is par decompoſed; a conſiderable quantity of acid-phle comes over, which is without ſmell or colour, and c ſiſts of the acid itſelf, ſcarcely altered; and the reſid affords vegetable alkali, amounting to ſomewhat m than one third of the weight of the ſalt. Expoſur air does not alter the ſalt of ſorrel. It is very ſp ingly ſoluble in cold water: but boiling water n take up one ſixth part, or more, of its weight; quantity varying according to the ſtate and purity the ſalt, which ſeems to vary in different ſpecimen

— characters:

— action upon various ſubſtances.

Salt of ſorrel acts upon various ſubſtances with decompoſition. With ponderous earth, magneſia, getable alkali, and volatile alkali, it forms triple ſ Lime decompoſes it by ſeizing the whole of the a and diſengaging the alkali. The attraction of acid for lime is ſo ſtrong, that it cannot be diſeng

Method of purifying the acid of ſorrel.

it by any other acid: another proceſs is there-
neceſſary to be uſed for obtaining it. With this
tion, the ſuperabundant acid is to be ſaturated
volatile alkali; and into this ſolution muſt be
d a ſolution of ponderous earth in the nitrous
The laſt-mentioned acid combines with the al-
forming nitrous ammoniac, and common nitre,
which remain in ſolution; while the ponderous
combining with the acid of ſorrel, forms an in-
le compound, which falls to the bottom. This
pitate, after being well waſhed, may be decom-
by the addition of vitriolic acid, which ſeizes
rth, and likewiſe forms an inſoluble combination,
the acid is ſet at liberty. After decantation of
ear liquid, it muſt be aſſayed by pouring into it a
at a time of the boiling hot ſolution of ponde-
earth in the acid of ſorrel. If there be any ex-
f vitriolic acid, a precipitate will be formed by
ion with the ponderous earth. A due evapora-
nd cooling of this liquor afford the acid of ſorrel,
ſmatic four-ſided cryſtals or ſquare plates.

Characters.

is acid has a conſiderable degree of ſtrength.
ed to heat in a retort, it falls into powder, with
ſs of three tenths of its weight, after which it
boils up, at the ſame time that its colour changes
rown. An acid phlegm comes over, and part
e acid ſublimes without alteration. Fixed air
nflammable air are diſengaged during this de-
oſition of the acid; and their quantity is greater,
ore violent the heat.

Combinations.

ling water diſſolves its own weight of this con-
acid ſalt, half of which is ſeparated in cryſtals
by

Combinations of the acid of ſorrel.

by cooling. It diſſolves clay, and affords a deliqu
cent maſs by evaporation. With ponderous ea
it forms a ſalt ſcarcely ſoluble, except there be
exceſs of acid; in which caſe it affords tranſpar
cryſtals, which become opake, powdery, and inſolub
when the exceſs of acid is taken up by boiling wa
With magneſia, it forms a white powdery ſalt;
with lime it forms an inſoluble compound, wh
cannot be decompoſed in the moiſt way, becauſe
affinities of theſe two ſubſtances are ſtronger than
which exiſt between either of them and other kno
bodies. From this property, the acid of ſorrel is
as the teſt of the preſence of lime, which it prec
tates from all its combinations.

Syntheſis.

If vegetable alkali be gradually added to a ſolu
of this acid in water, a precipitate falls down, w
is the ſalt of ſorrel, and contains the acid in exceſs
farther addition of alkali ſaturates the acid, and f
a very ſoluble ſalt, which is capable of cryſtallizin
the alkali be in exceſs. With an exceſs of the m
ral alkali it forms a ſalt of ſparing ſolubility.
volatile alkali it affords a cryſtallizable ſalt; and
both theſe alkalis, if the acid be in exceſs, it f
a leſs ſoluble ſalt, ſimilar to what happens with
vegetable alkali.

It acts on ſeveral of the metals directly, b
general combines more readily with their calces.

This acid does not differ from the acid of ſ
Treatment with nitrous acid converts it into ac
acid and fixed air; or totally into the latter, i
action be rapid.

C H

CHAP. V.

ERNING THE VEGETABLE ACIDS PRODUCED OR EVELOPED BY DESTRUCTIVE DISTILLATION, OR BY THE ACTION OF NITROUS ACID.

VEGETABLE ACIDS: ARTIFICIAL.

Conſiderations on the compoſition and decompoſition of vegetable bodies.

the courſe of the preceding accounts of the
getable acids, it may be obſerved, that they are
bject to great alterations by the action of che-
agents; and they are all ſubject to ſpontaneous
npoſition. They ſeem to obtain their acid pro-
s by the combination of a baſe with the vital
f the air, in the ſame manner as has been more
ſhewn with regard to the mineral acids; but they
r to be of too compounded a nature to retain
rder or arrangement of their component parts
gh thoſe great varieties of temperature, to which
neral the mineral acids may be ſubjected. Heat
the arrangement of their component parts, and
ates them from each other in a new form. The
cts of all vegetable ſubſtances including theſe
are found, when urged by fire, to be water, fixed
inflammable air, oil, coal, and alkali. If we
der water as decompoſable, and conſiſting of vital
nflammable air; if we conſider oil as compoſed
ed air and inflammable air; and again, whether
dmit charcoal to conſiſt chiefly of inflammable
ccording to the opinion of ſome chemiſts, or of
the

Simplicity and ſmall number of vegetable principles.

the peculiar baſis of fixed air, according to othe
and, laſtly, if fixed air be allowed to conſiſt of ch
coal united to vital air, whether the charcoal be c
ceived as a peculiar ſubſtance, or as inflammable
in a ſtate of condenſation; we ſhall at length
that the component parts of vegetables are very fe
inſomuch that, if the foregoing poſitions were cle
eſtabliſhed, they would conſiſt either of charcoal, v
air, and inflammable air, or elſe of vital air and
flammable air only. From the various proporti
of theſe, in different ſtates of condenſation, it wo
follow, that water, fixed air, oils, mucilages, and ac
are produced; and that the beautiful variety of na
ariſes from this arrangement and combination.

Empyreumatic acids.

The firſt action of fire upon the vegetable a
does not in general alter their combinations ſo m
but that ſome other acid comes over together
the elaſtic products. Theſe acids, which on acco
of the peculiar ſmell which they obtain from the
are called empyreumatic, would probably, on exa
nation, be found to be of various kinds. Thoſe w
have hitherto engaged the attention of chemiſts,
the empyreumatic acid of tartar; the empyreum
acid of ſugar or mucilage, formerly called ſpiri
honey; and the empyreumatic acid of wood, whic
ſuppoſed to be the ſame in all woods, and has
diſtinguiſhed by the name of ſpirit of box.

Empyreumatic acid of tartar.

The empyreumatic acid of tartar, is the acid phl
which comes over when cream of tartar is exp
to diſtillation. This acid is impure, on accoun
ſome oil which comes over with it, and from w

Empyreumatic acid of tartar:

n only be ſeparated by the funnel; becauſe it di- ſo ſuddenly, when an attempt is made to rectify y a ſecond diſtillation, that it burſts the veſſels. acid properties of this fluid are ſufficiently appa- , though it does not redden the tincture of violets, does turnſole and blue paper. It forms peculiar pounds with the earths and alkalis, which have been much examined, but are very different from e afforded by the acid of tartar.

— of ſugar or mucilage:

Vhen inſipid gummy ſaccharine or farinaceous mu- ges are expoſed to diſtillation, an empyreumatic comes over, of a reddiſh yellow colour, and a er, acrid, and ſour taſte. By rectification with the ition of clay, the acid comes over clear, and leſs yreumatic. It does not afford cryſtals, but may oncentrated by freezing, which converts its aque- part into ice. In this ſtate it ſtrongly reddens vegetable colours, and forms a red ſpot where it on the ſkin. By diſtillation, cautiouſly managed loſe veſſels, it may be converted for the moſt part fixed and inflammable air.

he empyreumatic acid of ſugar attacks and diſ- es the ſoluble earths and alkalis. It corrodes lead, per, tin, and iron: but the compounds it forms theſe bodies have been little attended to.

— of wood.

ox, birch, and other woods, when expoſed to diſ- tion, afford that peculiar acid, which is ſo offenſive he eyes when the ſmoke of a ſmothering wood forces itſelf into an apartment. This acid has ſiderable ſtrength. The oil which comes over with

VEGETABLE ACIDS: ARTIFICIAL.

Acid of wood.

with it, may be ſeparated, either by ſtanding for ſome months, or by rectification. It cannot be obtained in a concrete form. A ſtrong heat decompoſes it. With earthy and alkaline baſes it forms peculiar ſalts, whoſe general properties have not been minutely enquired into. As the properties of the acid obtained from a conſiderable variety of woods have proved to be the ſame, it is preſumed that all woods contain this common acid, or at leaſt that combination of principles which conſtitutes its baſe.

Obſervations on the effect of nitrous acid upon vegetable bodies.

Since the acidification of combuſtible ſubſtances is evidently produced by the application or combination of vital air; and as, in all the operations of chemiſtry, effects may be produced by one mode of combination, which are impracticable in others; it becomes neceſſary, in chemical reſearches, to try every means which can be deviſed. Few vegetable acids are artificially produced by the direct application of vital air to the principles of that claſs of bodies; but many experiments have been made by abſtracting the nitrous aci from vegetables by diſtillation. This acid, as we have frequently had occaſion to obſerve, is very eaſily de compoſed, when applied to combuſtible bodies, which attract its vital air, and diſengage either nitrous o phlogiſticated air, as we have explained in our chapte upon that acid. It has likewiſe been obſerved, in v rious parts of the preſent ſection, that this acid, whe repeatedly diſtilled from gums, mucilages, ſugar, th acids of tartar, of apples, and of gall, produces th peculiar acid which has been called the acid of ſugar and, if the abſtraction be repeated too often, the aci

Chap. III. IV.

igar itſelf is converted into fixed air. From this of the ſubject, together with other facts, it has inferred, that a greater or leſs proportion of vital united with one general principle abundantly ing in charcoal, whether this principle be inflam- e air or not, produces all the various acids of tables. Thus tartar, which is the leaſt acidified, d to become converted into the acid of apples by ment with nitrous acid. The acid of apples, by ntinuance of the operation, becomes converted acid of ſugar, or acid of ſorrel, which are the thing. The ſame proceſs, further continued, ds vinegar*, which comes over. Hence it d ſeem that, according to the greater progreſs h the operation of combuſtion, or the combi- n of vital air with the baſe (which at the ſame according to the ancient theory, is ſuppoſed to ore dephlogiſticated), the acids of tartar, of s or unripe fruit, of ſorrel or ſugar, of vinegar, aſtly, of fixed air, are produced. In this order roceeding, the acids become more and more ct, and leſs eaſily decompoſable: and on this nt probably it is, that attempts to reverſe the ſſes have not hitherto been attended with much ſs.

The progreſs of acidification in vegetable bodies.

Difference between the acids of ſugar and ſorrel.

ce the diſcovery that the acid of ſugar does not from that of ſorrel but in containing a ſmall rtion of alkali, the procuring of the former in xpenſive way of diſtillation with nitrous acid, is become unneceſſary. We ſhall, nevertheleſs, deſcribe the proceſs here, as an example of that method of operating.

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* e Scheele's Eſſays, Engliſh tranſlation, page 385; and the l de Phyſique for January 1788, page 59.

The proceſs for converting ſugar into an acid.

Three ounces of ſtrong nitrous acid, whoſe ſpecific gravity was nearly 1.567, were mixed in a tubulated retort with one ounce of the fineſt ſugar in powder. Much nitrous air eſcaped in red fumes, formed by combination with the vital air of the atmoſphere. A receiver was then adapted, and the liquor gently boiled. As ſoon as the mixture had acquired a dark brown colour, three additional ounces of nitrous acid were added, and the boiling was continued until the coloured and fuming acid had entirely diſappeared. The liquor being then poured out, afforde ſmall priſmatic cryſtals by cooling, which are the aci of ſugar. The lixivium being again treated in th ſame manner, with two ounces of nitrous acid, afforded an additional portion of acid of ſugar by cooling and the remaining glutinous liquor, treated at differen times with ſmall quantities of nitrous acid, amounting in the whole to two ounces, and evaporated t dryneſs, afforded a ſaline maſs: and, laſtly, the whol was depurated by repeated ſolutions and cryſtalliz tions in water. In this way, with three parts of ſuga and thirty of nitrous acid, the quantity of one part o acid of ſugar is obtained.

Obſervation.

The above proceſs is taken from Bergmann: but may be obſerved that weak nitrous acid, or commo aqua fortis, will anſwer the purpoſe as well as t concentrated acid; and that, where it is not an obje to collect the acid which comes over, there will no need of any receiver, or other apparatus, except

matra

VEGETABLE ACIDS: ARTIFICIAL.

raſs, or Florence flaſk, to perform the operation
chimney where there is a proper draught of air
arry off the acid fumes.

Acid of camphor.

he acid of camphor* is produced by diſtilling the
ous acid eight ſucceſſive times from camphor. It
f a concrete cryſtalline form, of a bitter taſte, and
lens the tinctures of violets and turnſole. It dif-
from the acid of ſugar in not ſeparating lime
n the marine acid. With vegetable alkali it forms
lt in regular hexagons; with mineral alkali, a ſalt
rregular cryſtals; with volatile alkali, priſmatic or
dle-formed cryſtals; and with magneſia, a pulve-
nt ſoluble ſalt. It diſſolves ſeveral metallic ſub-
ces. But ſubſequent enquiries are wanting to
bliſh the peculiar nature and properties of this
..

Acid of cork.

y diſtilling four times its weight of nitrous acid
n cork, a yellowiſh thick acid matter is obtained,
ch is ſoluble in water, and has an auſtere bitteriſh
e. It does not cryſtallize, but becomes conſiſtent
wax by evaporation; is ſoluble in ardent ſpirit;
ns deliqueſcent ſalts with the earths and alkalis;
has as ſtrong an attraction for lime as the acid of
ar †.

Koſegarten, Nouv. de la Republ. des. Lettres, Année 1785.
. 42 and 44; quoted by Fourcroy, Elem. Chem. iv. 104,
on of 1789.

Brugnatelli, in the Journal de Phyſique, Auguſt 1787; or
l's Annals for the ſame year.

CHAP. VI.

ON THE DESTRUCTIVE DISTILLATION OF VEGETABLE SUBSTANCES.

VEGETABLE PRODUCTS BY FIRE.

Deſtructive diſtillation.

IN the foregoing chapters we have occaſionally treated of the decompoſition of vegetables by deſtructive diſtillation, and have deſcribed the volatile products it affords. As the immediate principles of organized ſubſtances are for the moſt part very compounded, and the extreme temperature produced in this method tends to reduce them to their primary component parts, it is evident that very little can be learned in this way concerning that on which the various properties of thoſe ſubſtances depend. But as the chemiſt ought to neglect none of the methods he poſſeſſes of producing changes in bodies, this proceſs may have its uſe when compared with others, and more eſpecially when we ſhall have arrived at that knowledge of the firſt principles of organized ſubſtances, which from a variety of facts, and the late rapid progreſs of chemiſtry, we have reaſon to hope for. We ſhall therefore proceed to deſcribe the general phenomena of deſtructive diſtillation.

This proceſs conſiſts merely in expoſing any organized ſubſtance to heat in a retort, placed in a reverberatory furnace. The ancient chemiſts, who paid no attention to the claſtic products, except ſo far as their

r expanſive force impeded their operations, uſually
led a ſmall hole in the upper part of the receiver for
r eſcape. Modern chemiſtry proceeds in a more
ntific manner, by uſing the pneumatic apparatus,
21. The firſt product which comes over in the
illation of vegetables, is a watery fluid, contain-
acid and odorant principles. In proportion as the
ruction of the vegetable proceeds, the phlegm be-
es deeper coloured, and more ſaline. Next fol-
; a coloured oil, which becomes of a darker hue
ne diſtillation proceeds, and varies greatly accord-
to the nature of the plant; for it conſiſts chiefly
ne eſſential oil, which comes over in a foul ſtate,
differs in its fixity, denſity, fuſibility, and all its
r properties according to the nature and quantity
he eſſential oil which predominates in it. All
products obtained in this way have a peculiar
ed ſmell, which chemiſts diſtinguiſh by the name
npyreumatic. If the vegetable contain volatile
, or its component parts, this ſubſtance uſually
nes when the oil comes over. The elaſtic fluids
n paſs into the apparatus of inverted veſſels are
y inflammable air, or fixed air, or a mixture of
(probably in combination), which is heavier than
inflammable air, and burns with a lambent blue
inſtead of detonating like that elaſtic fluid.
eat muſt be very gradually raiſed, and the re-
s changed from time to time, in this method of
poſition; otherwiſe the products which come
will be confounded together, and the reſults will
rſe be more fallacious than they would otherwiſe
een. The fixed reſidue conſiſts of charcoal, a

Decompoſition of vegetables by fire.

ſmall portion of alkali, and a very minute quantity of earth.

Empyreumatic oils.

The empyreumatic oils which come over in theſe diſtillations may all be rendered colourleſs, and ſoluble in ardent ſpirit by rectification. In this manner it appears therefore that the fixed oils of vegetables are converted into volatile or eſſential oils; from which, as well as from other circumſtances, it is rendered probable that theſe oils differ from each other only in the proportion of their component parts.

Charcoal:

The black, ſonorous, brittle, light ſubſtance, called charcoal, uſually retains the figure of the vegetable from which it was produced, unleſs the greater par of the vegetable conſiſted of fluids, which, in their diſſipation, deſtroy the connection of the more fixed parts. In the latter caſe the quantity of charcoal much leſs than in the former. It is a ſingular fact that this ſubſtance, when well burned, is a perfec conductor of electricity; though the electric matt is not conveyed at all through wood which is ſimp baked or dried. The charcoal of oily or bituminou ſubſtances is of a light pulverulent form, and riſes i ſoot. This charcoal of oils is called lamp-black.

—conducts electricity:

—reſiſts heat, and abſorbs elaſtic fluids:

Charcoal reſiſts the moſt violent heat in cloſ veſſels. If it be ignited, it abſorbs elaſtic fluids wi great avidity as it cools; and it retains the prope if cooled by immerſion in mercury, the abſorpti being equally conſiderable when it is afterwards poſed to the air.

—exceedingly combuſtible.

The diſpoſition to be burned, which in the cient theory is ſuppoſed to conſiſt in the giving of phlogiſton, and in the modern theory in the

ſorp

Charcoal.

ption of vital air, is ſo great in charcoal, that it forms the reverſe of combuſtion with a great iety of ſubſtances. Thus it converts the vitriolic d into vitriolic air, by augmenting the proportion ſulphur; and it is ſtrongly acted on by the nitrous l, much nitrous air being extricated at the ſame e. The rapidity with which the nitrous acid s upon perfectly dry charcoal, has been already ntioned. In either of theſe proceſſes, the acid ier combines ſuddenly with the phlogiſton of the rcoal, or the vital air of the acid combines with charcoal itſelf, conſidered as a ſimple ſubſtance.

Page 165.

The moſt violent combuſtion of nitre with charcoal, which the acid is entirely decompoſed, and gives phlogiſticated air, may be explained in the ſame y by each theory.

Solubility of charcoal.

Alkalis diſſolve charcoal in the dry way; and liver ſulphur combines very readily with it, either in the or humid way. All the metallic ſubſtances hi-rto known are leſs combuſtible than charcoal, and ſequently are revived, or reduced to the metallic e, by being heated with this ſubſtance. This, in ancient theory, denotes that all the metals attract ogiſton more ſtrongly than charcoal does; but in new theory the effect is aſcribed to the ſtronger action of charcoal, which deprives all metallic es of the vital air which combined with them ing their calcination.

Revivification.

Obſervation.

An important conſequence ſeems to follow from circumſtance; namely, that there may exiſt many tallic ſubſtances whoſe combuſtibility may be ater than that of charcoal; and which conſequently

VEGETABLE PRODUCTS BY FIRE.

quently are unknown to us as ſuch, becauſe we poſſeſs no means of reducing them. Thus the alkalis and earths may conſiſt of peculiar combuſtible or metallic ſubſtances, either dephlogiſticated, or combined with vital air, by an union which the art of chemiſtry has not yet found means to break.

Combuſtion of charcoal.

When charcoal is expoſed to heat in open veſſels, it burns with a light flame, nearly tranſparent, emitting very little light, and no ſmoke. The reſidue conſiſts of a ſmall quantity of aſhes, which contain fixed alkaline and neutral ſalts. The fixed vegetable alkali is obtained from the aſhes of various plants, under the name of pot-aſh or pearl-aſh, and is not eaſily purified from the neutral ſalts it may be contaminated with. Mineral alkali is obtained by incineration only from marine plants. The neutral ſalts found in the aſhes of vegetables are vitriolated tartar, Glauber's ſalt and ſelenite, common ſalt, and ſalt of Sylvius. Calces of iron and of manganeſe, with an earthy ſubſtance, compoſe the inſoluble reſidue. What this earthy ſubſtance is has not been determined; but it moſt probably conſiſts of ſome inſoluble earthy ſalt, ſuch as phoſphorated lime.

Reſidual ſalts.

CHAP. VII.

CONCERNING FERMENTATION IN GENERAL.

FERMENTATION.

The ſpontaneous decompoſition of vegetables.

Three ſtages of fermentation:

—vinous:

—acetous:

Page 459.

—putrid:

HE word Fermentation, in an enlarged ſenſe, is
uſed to denote that change of the principles of
anic bodies, which begins to take place ſpontane-
ly as ſoon as their vital functions have ceaſed, and
which they are at length reduced to their firſt prin-
es. This has been diſtinguiſhed into three ſtages;
vinous or ſpirituous, the acid or acetous, and
putrid fermentation; which are ſo called from the
icipal products obtained during their action. All
anized bodies are not ſubject to the three degrees
fermentation. It is aſcertained almoſt beyond a
bt that the vinous fermentation takes place only
uch bodies as contain ſaccharine juices. In this
moſt remarkable product is a volatile, colourleſs,
t, inflammable fluid, which mixes with water
all proportions, and is called ardent ſpirit. The
tous fermentation is diſtinguiſhed by the product
wn by the name of vinegar, which is the leaſt de-
ctible of the vegetable acids. It does not appear,
vever, that fermentation is abſolutely neceſſary for
production of this acid, as there are other chemical
ans by which it may be obtained, or produced. In
putrid fermentation, bodies appear to be reduced
their moſt ſimple parts. Volatile alkali is the
duct which has been remarked as the chief in this
proceſs,

Stages of fermentation.

proceſs, and is no doubt produced by the combination of inflammable and phlogiſticated air, which fly off together. The acetous, like the vinous fermentation, is confined to vegetable ſubſtances; but the putrefactive proceſs is moſt eminently perceived in animal bodies. Theſe either putrefy immediately; or, if the putrefaction be preceded by either of the other ſtages, their duration is too ſhort to be perceived. It is conſidered as an eſtabliſhed fact, that the three ſtages of fermentation always follow in the ſame order, in ſuch bodies as are ſuſceptible of them all; the vinous coming firſt, which is followed by the acetous and the putrefactive proceſſes.

Conditions or circumſtances requiſite to the progreſs of fermentation.

The ſpontaneous decompoſition of bodies is greatly retarded by extreme cold, by ſudden drying of the parts, or by preſervation in cloſed veſſels. The two firſt circumſtances neceſſarily retard the chemical effects, by depriving the parts of that fluidity which is almoſt indiſpenſably neceſſary in chemical proceſſes. It will eaſily be underſtood that the third circumſtanc will retard the ſpontaneous decompoſition of bodie when it is conſidered that the atmoſphere itſelf is th ſolvent and receptacle of many of the component part of bodies with which it is diſpoſed to combine. I well-cloſed veſſels, the parts of organized bodies whic are diſpoſed to fly off in the elaſtic ſtate, are pr vented from eſcaping; and ſuch parts as might forn new combinations, by abſorbing either the content or component parts of the atmoſphere, are prevente for want of a free communication. The three co ditions for the accompliſhment of fermentation ar

ther

efore, fluidity or moiſture, moderate heat or a temperature, and the acceſs of air: and the fer- :tation will likewiſe be modified according to the ɔus component parts of bodies.

Vinous fermentation deſcribed, as it takes place in ſugar and water.

ı deſcribing the vinous decompoſition of vegeta- ,, it will be of advantage to attend to that of mere ır and water; the phenomena in theſe being e diſtinct, becauſe leſs modified by foreign ad- ture. If a conſiderable quantity of water, holding olution about one third of its weight of ſugar, be oſed to the air at the temperature of about 70 rees, after the addition of a ſmall quantity of ſt, it ſoon undergoes a remarkable change. In the rſe of a few hours the fluid becomes turbid and :hy; bubbles of fixed air are diſengaged, which riſe break at the ſurface. The diſengagement becomes ıre and more abundant; mucilage is ſeparated, part which ſubſides to the bottom; and part, expanded ɔ froth by the elaſtic fluid, forms yeaſt. During courſe of ſeveral days, theſe effects gradually ne to their height, and diminiſh again; after ich they proeeed very ſlowly, but are long before :y entirely ceaſe. The fermented liquor has no ıger the ſweet taſte it had before, but becomes ſk and lively, with a pungent ſpirituous flavour. ſpecific gravity likewiſe is conſiderably leſs than ore; and, when expoſed to diſtillation, it affords a ht inflammable ſpirit. The quantity of ardent rit which any fermented liquor will produce, is ɔught to follow ſome proportion of the change its ːcific gravity undergoes in fermentation; but the truth

Yeaſt.

Inflammable ſpirit.

truth of this has not been clearly aſcertained *. Wine, cyder, and beer, are well-known liquors of this kind.

Acetous fermentation.

It is uſual to put fermented liquors into caſks before the vinous fermentation is completely ended; and in theſe cloſed veſſels it goes on for many months. But if the fermentative proceſs be ſuffered to proceed in open veſſels, more eſpecially if the temperature be raiſed to 90 degrees, the acetous fermentation comes on. In this the vital part of the air is gradually abſorbed; and the more ſpeedily, in proportion as the ſurfaces of the liquor are oftener changed by lading it from one veſſel to another. The uſual method conſiſts in expoſing the fermented liquor to the air in caſks, placed ſo that the ſun may ſhine on them; which ſeems to be of advantage, by raiſing the temperature of the liquor. By this abſorption of vital air, the inflammable ſubſtance becomes converted into an acid. If the liquid be then expoſed to diſtillation, pure vinegar comes over, inſtead of ardent ſpirit.

Putrefaction.

When the ſpontaneous decompoſition is ſuffered to proceed beyond the acetous proceſs, the vinegar gradually becomes viſcid and foul; air is emitted, with an offenſive ſmell; volatile alkali flies off; an earthy ſediment is depoſited; and the remaining liquid, if any, is mere water. This is the putrefactive proceſs.

Though fermentation is much better underſtood at preſent, in conſequence of modern reſearches into the

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* Richardſon on Brewing.

nature

FERMENTATION.

The effect of yeaſt in fermentation.

e of elaſtic fluids, than it formerly was, it ſtill
ins an intereſting object of reſearch. It is not
y aſcertained what the yeaſt or fermented matter
rms in this operation. It ſeems probable that the
ntative proceſs, in conſiderable maſſes, would be
d on in ſucceſſion, from the ſurface downwards;
would perhaps be completed in one part of the
before it was perfectly begun in another part, if
aſt, which is already in a ſtate of fermentation,
ot occaſion the proceſs to begin in every part of
uid at once. Much remains to be done towards
aining the arrangement and quantity of the com-
t parts of ardent ſpirit: and the theory of fixed
ith the identity of inflammable airs, muſt be
ained, before any decided reaſoning can be
d on this head. It ſeems however that inflam-
air, in combination with fixed air in certain
tions, forms ardent ſpirit; that a greater pro-
n of vital air converts it into vinegar; and that,
putrefactive proceſs, the inflammable air, the
air, and the vital air, are ſeparated from each
and fly off in the elaſtic ſtate.

Component parts of ardent ſpirit, &c.

Tartar.

he fermentation of wine, the tartar, which pro-
exiſted for the moſt part ready formed in the
f the grape, is ſeparated, and exhibits the pro-
which have been already deſcribed in treating
t ſubſtance.

Bread.

fermentation of bread by leaven is thought to
a different nature from the vinous fermentation.
s the mucilage of the corn is not previouſly
t into the ſaccharine ſtate. It quickly becomes
ſour,

FERMENTATION.
Bread.

ſour, if the proceſs be not ſtopped by baking; in which particular, the fermentation ſeems to be o the acetous kind. The development of fixed ai divides the dough into thin parts, which are mor effectually and better baked than they could hav been in the ſolid conſiſtent maſs. When bread i fermented by means of yeaſt, the proceſs appears be of a ſaccharine or vinous nature.

C H

C H A P. VIII.

CERNING VINOUS FLUIDS AND ARDENT SPIRIT.

VINOUS FLUIDS.

The making of wine from grapes.

ROM the habits of ſociety, the making of wine,
beer, and ardent ſpirits, is become an object of
derable importance. Wine is the expreſſed juice
e grape which has undergone the firſt ſtage of
entation. In this, which in general appears to
e beſt kind of fermented liquor, there are great
ences, which depend no leſs on the kind and
ty of the fruit than on the proceſs of manu-
ring. If the fruit be gathered unripe, the juice
bound with acid, and the wine will be thin and
; but, if the fruit be ripe, it will contain much
arine juice, and the wine will be ſweeter. If
ine be caſked in an early ſtage of the fermenta-
much of the ſugar will remain undecompoſed,
he wine will be ſweeter on that account, eſpe-
if the fermentation be checked by a conſiderable
e of cold; but, on the contrary, when the pro-
of the fermentation is only impeded by the coer-
of the veſſel, which prevents the eſcape of the
air, a ſlight increaſe of temperature, ſuch as
of a room in a dwelling-houſe compared with
emperature of a cellar, will cauſe it to proceed
great rapidity as ſoon as the veſſel is opened.
s in this ſtate are very briſk and lively, from
redominating acidity of the fixed air, which is
y diſengaged.

Beer

The malting of barley:

Beer is the wine of grain. Malt is uſually made of barley. This grain is ſteeped for two or three days in water till it ſwells, becomes ſomewhat tender, and tinges the water of a bright reddiſh brown colour. The water being then drained away, the barley i ſpread about two feet thick upon a floor, where it heats ſpontaneouſly, and begins to grow, by fir ſhooting out the radicle. In this ſtate the germinatio is ſtopped, by ſpreading it thinner, and frequentl turning it over for two days; after which, it is agai made into an heap, and ſuffered to become ſenſibl hot, which uſually happens in little more than a da Laſtly, it is conveyed to the kiln, where, by a gra dual and low heat, it is rendered dry and criſp. Thi is malt; and its qualities differ according as it i more or leſs ſoaked, drained, germinated, dried, an baked. In this, as in other manufactories, the inte ligent operators often make a myſtery of their pr ceſſes, from views of profit; and others pretend peculiar ſecrets, who really poſſeſs none.

— of Indian corn.

Indian corn, and probably all large grain, requi to be ſuffered to grow into the blade, as well as roo before it is fit to be made into malt. For this pu poſe, it is buried about two or three inches deep the ground, and covered with looſe earth; and in t or twelve days it ſprings up. In this ſtate it is tak up and waſhed, or fanned, to clear it from its d and then dried in the kiln for uſe.

Brewing of beer.

Beer is made from malt previouſly ground, or cut pieces by a mill. This is placed in a tun, or tub, w a falſe bottom; hot water is poured upon it, and whole ſtirred about with a proper inſtrument. T

ten

Brewing of beer.

erature of the water in this operation, called
ing, muſt not be equal to boiling; for in that
the malt would be converted into a paſte, from
h the impregnated water could not be ſeparated.
r the infuſion has remained for ſome time upon
nalt, it is drawn off, and is then diſtinguiſhed by
ame of ſweet wort. By one or more ſubſequent
ions of water, a quantity of weaker wort is ob-
d, which is either added to the foregoing, or
apart, according to the intention of the ope-
. The wort is then boiled with hops, which
it an aromatic bitter taſte, and are ſuppoſed to
r it leſs liable to be ſpoiled in keeping; after
h, it is cooled in ſhallow veſſels, and ſuffered to
nt, with the addition of a proper quantity of
. The fermented liquor is beer; and differs
ly in its quality, according to the nature of the
, the malting, the maſhing, the quantity and kind
e hops and the yeaſt, the purity or admixtures of
vater made uſe of, the temperature and viciſſi-
of the weather, &c.

Metheglin and koumiſs.

ſides wine and beer, which are made immedi-
from vegetables; other fermented liquors, con-
g ardent ſpirit, are made from honey and from
s milk. The former is called metheglin; and
tter, which is made by the Tartars, koumiſs *.
laſt is made by agitating the milk, at the time
its parts begin to ſeparate, by a fermentation
ctive of a peculiar acid, called the acid of milk,
fter to be deſcribed.

Grieve, in the Edinburgh Tranſactions, vol. i. p. 181.

ARDENT SPIRIT.

Product of vinous liquors by diſtillation.

In order to obtain ardent ſpirit, nothing more is neceſſary than to expoſe wine, beer, or any other fer- mented vinous liquid, to diſtillation; and the product which comes over is the ardent ſpirit itſelf, contami- nated with eſſential oil. If this be rectified by a ſe- cond diſtillation, it becomes much purer. The moſt volatile part riſes firſt, and is of a leſs ſpecific gravity than that which comes over afterwards.

Reſidue.

The reſidue, after the diſtillation of ardent ſpirit from wine, is of a deep colour, a rough acid taſte, and depoſits cryſtals of tartar. The colouring matter is ſoluble in ardent ſpirit. So that it appears, from this imperfect analyſis, that wine conſiſts of water, ardent ſpirit, colouring matter of a reſinous nature, ſugar, tartar, and tartareous acid, and an aromati principle.

Strength of ardent ſpirit determined by M. Bories.

The ſtrength or purity of ardent ſpirit is aſce tained from its ſpecific gravity; for the addition o water renders it heavier. According to M. Bories whoſe Memoir, publiſhed at Montpellier in the yea 1774, obtained the prize propoſed by the ſtates o Languedoc in 1772, the ſpecific gravity of rectifie ardent ſpirit repeatedly poured on dry ſalt of tart till it would no longer diſſolve or liquefy it, was foun by many experiments to be as follows:

Reaumur's Therm. + 10° = 820 $\frac{2000}{5035}$
15° = 817 $\frac{65}{5035}$
20° = 813 $\frac{2284}{5035}$

The ſpecific gravities of mixtures, by meaſure, the foregoing ſpirit with diſtilled water, were follows:

Tem

ARDENT SPIRIT.

Specific gravities of various mixtures of water and ſpirit.

emperature + 15° Reaumur.

irit	10	Water	0	Specific gravity	$817\frac{65}{5055}$
	9	—	1	— —	$844\frac{3580}{5055}$
	8	—	2	— —	$869\frac{4705}{5055}$
	7	—	3	— —	$893\frac{1895}{5055}$
	6	—	4	— —	$915\frac{925}{5055}$
	5	—	5	— —	$934\frac{3630}{5055}$
	4	—	6	— —	$951\frac{3695}{5055}$
	3	—	7	— —	$965\frac{1925}{5055}$
	2	—	8	— —	$976\frac{1320}{5055}$
	1	—	9	— —	$987\frac{715}{5055}$
	0	—	10	— —	1,000

Obſervations.

pon the above experiments, which are among the
accurate we poſſeſs *, it may be obſerved, that
firſt term, or pure ſpirit, ought to be obtained
an alkali perfectly mild, or ſaturated with fixed
becauſe, otherwiſe, ſolution and combination of
lkali with the ſpirit might take place. By diſtil-
n of twenty meaſures of the beſt ardent ſpirit of
ſhops, whoſe ſpecific gravity was 0.836 over a
in glaſs veſſels, I found the firſt meaſure which
e over had a ſpecific gravity of 820, at the tem-
ture of 71° Fahrenheit; which anſwers to 17⅓ of
umur. This is the ſtrongeſt ſpirit mere diſtilla-
can afford. When ſtrong ardent ſpirit is added
ater, a conſiderable heat is produced, a few bub-
of air are emitted, the mixture contracts in
limenſions, and acquires a greater ſpecific gravity
would have been deduced by computation.

Strongeſt ardent ſpirit by mere diſtillation.

See a very valuable ſet of experiments on this ſubject by Mr.
in; of which Dr. Blagden has made a report in the Phil.
ſ. lxxx. 321.

ARDENT SPIRIT.

Requiſites or deſiderata to aſcertain the ſtrength of ſpirit.

It is by no means an eaſy undertaking to determine the ſtrength or relative value of ardent ſpirit, even with ſufficient accuracy for commercial purpoſes. The following requiſites muſt be obtained before this can be well done: The ſpecific gravity of a certain number of mixtures of ardent ſpirit and water muſt be taken ſo near each other, as that the intermediate ſpecific gravities may not perceptibly differ from thoſe deduced from the ſuppoſition of a mere mixture of the fluids: the expanſions, or variations of ſpecific gravity, in theſe mixtures, muſt be determined at different temperatures: ſome eaſy method muſt be contrived of determining the preſence and quantity of ſaccharine or oleaginous matter which the ſpirit may hold in ſolution, and the effect of ſuch ſolution on the ſpecific gravity: and, laſtly, the ſpecific gravity of the fluid muſt be aſcertained by a proper floating inſtrument with a graduated ſtem, or ſet of weights; or, which may be more convenient, with both.

Phial proof.

The ſtrength of brandies in commerce is judged by the phial, or by burning. The phial proof conſiſts in agitating the ſpirit in a bottle, and obſerving the form and magnitude of the bubbles, which are larger the ſtronger the ſpirit. Theſe probably depend on the ſolution of reſinous matter from the caſk, which is taken up in greater quantities, the ſtronger the ſpirit. It is not difficult however to produce this appearance, by various ſimple additions to weak ſpirit.—The proof by burning is alſo fallacious; becauſe the magnitude of the flame, and quantity of reſidue, in the ſame ſpirit, vary greatly with the form of the veſſel it is burned

Proof by burning.

ned in. If the veſſel be kept cool, or ſuffered to ome hot, if it be deeper or ſhallower, the reſults not be the ſame in each caſe. It does not follow, vever, but that manufacturers and others may in ny inſtances receive conſiderable information from e ſigns, in circumſtances exactly alike, and in the rſe of operations wherein it would be inconve- it to recur continually to experiments of ſpecific vity.

Characters and component parts of ardent ſpirit:

he moſt remarkable characteriſtic property of ent ſpirit, is its ſolubility or combination in all portions with water; a property poſſeſſed by no er combuſtible ſubſtance. When it is burned in a nney which communicates with the worm-pipe of a illing apparatus, the product which is condenſed ound to conſiſt of water, which exceeds the ſpirit weight about one eighth part. If ardent ſpirit be ned in cloſed veſſels with vital air, the product is nd to be water and fixed air. Whence it is in- ed, that ardent ſpirit conſiſts of inflammable air, ed either to fixed air, or its acidifiable baſe; and the vital air, uniting on the one part with in- mable air, forms water; and, on the other, with baſe of the fixed air, and forms that acid *.

— its uſes and combinations.

conſiderable number of the uſes of this fluid, as enſtruum, have already paſſed under our obſer- on. The mutual action between ardent ſpirit and

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For an account of theſe experiments, and the precautions ſſary to be attended to in making them, conſult the Memoirs I. Lavoiſier, in the Memoirs of the Royal Academy at Paris 781 and 1784.

Mutual action of ardent ſpirit and ſalts:

acids, produces a light, volatile and inflammable oil, called ether. Pure alkalis unite with ſpirit of wine, and form alkaline tinctures. Few of the neutral ſalts unite with this fluid, except ſuch as contain the volatile alkali. The mild fixed alkalis, or combinations of alkali and fixed air, are not ſoluble in it. From the ſtrong attraction which exiſts between ardent ſpirit and water, it unites with this laſt in ſaline ſolutions, and in moſt caſes precipitates the ſalt. This is a pleaſing experiment, which never fails to ſurpriſe thoſe who are unacquainted with chemical effects If, for example, a ſaturated ſolution of nitre in water be taken, and an equal quantity of ſtrong ſpirit o wine be poured upon it, the mixture will conſtitute weaker ſpirit, which is incapable of holding the nitr in ſolution; it therefore falls to the bottom inſtantly in the form of minute cryſtals. Among the neutr ſalts which are ſoluble in ſpirit of wine, the deliqueſ cent earthy ſalts ſtand firſt. Moſt ammoniacal ſalt are ſoluble in this menſtruum; and in general it com bines more readily with ſuch as have their acid le adherent to the neutralizing baſe.

— and ſulphur:

Sulphur does not appear to be acted on mor ſtrongly by ardent ſpirit than by water. If ſulphur i ſublimation meet with the vapour of ſpirit of wine, very ſmall portion combines with it, which commun cates an hepatic odour to the fluid. The increaſe ſurface of the two ſubſtances appears to favour th combination.

— and phoſphorus.

Phoſphorus is ſparingly ſoluble in ardent ſpiri but in greater quantity by heat than in the cold. Th addition of water to this ſolution affords an opal

mil

ARDENT SPIRIT.

ilky fluid which gradually becomes clear by the ſub-ience of the phoſphorus.

— and earths.

Earths ſeem to have ſcarce any action upon ardent irit. Quick-lime however produces ſome alteration this fluid, by changing its flavour, and rendering of a yellow colour. A ſmall portion is probably ken up.

Spirituous ſolutions.

Soaps are diſſolved with great facility in ardent irit, with which they combine more readily than ith water. None of the metals, nor their calces, e acted upon by this fluid. Reſins, eſſential oils, mphor, bitumen, and various other ſubſtances, are iſſolved with great facility in ardent ſpirit, from hich they may be precipitated by the addition of ater.

CHAP. IX.

CONCERNING THOSE INFLAMMABLE FLUIDS WHICH ARE PRODUCED BY THE ACTION OF ACIDS UPON SPIRIT OF WINE, AND ARE KNOWN BY THE NAME OF ETHER.

ETHER.

The making of vitriolic ether.

WHEN ſtrong vitriolic acid is poured upon an equal meaſure of rectified ſpirit of wine, the two fluids unite together, with a hiſſing noiſe and the production of heat, at the ſame time that a fragrant vegetable ſmell is emitted, reſembling that of apples: it is more advantageous, however, to add the acid in ſo gradual a manner as to produce little or no heat. If the mixture be made in a retort, and then expoſed to diſtillation by a well-regulated heat in a ſand-bath, a large receiver being adapted, and kept cool by immerſion in water, or by the frequent application of wet cloths, the volatile products may be ſafely condenſed. Spirit of wine of a fragrant ſmell comes over firſt, and is followed by the ether, as ſoon as the fluid in the retort begins to boil. At this period the upper part of the receiver is covered with large diſtinct ſtreams of the fluid, which run down its ſides. After the ether has paſſed over, volatile ſulphureous acid ariſes, which is known by its white fumes and peculiar ſmell. The receiver muſt now be removed, and another ſubſtituted in its place, care being taken to avoid breathing the penetrating fumes of the acid.

Th

Diſtillation of vitriolic ether.

e fire muſt at the ſame time be moderated, becauſe reſidue in the retort is diſpoſed to ſwell. A ht yellow oil, called ſweet oil of wine, comes r after the ether, and this is ſucceeded by black l foul vitriolic acid. The reſidue varies in its pro- ties according to the management of the heat. If fire be much increaſed towards the end of the ceſs, the volatile vitriolic acid which comes over l be mixed with vinegar. If the remaining fluid tained in the retort, after the ether has paſſed r, be not urged farther, it may be made to afford re ether, by the addition of one-third of very ng ardent ſpirit; and this may be repeated ſucceſſ ly, until near twice the quantity of the ſpirit origi- y made uſe of has been added.

Rectification.

ther of the firſt diſtillation is not pure, but con- s ſpirit of wine and ſulphureous acid, which may eparated by the addition of a fixed alkali, and rec- ing with a gentle heat. In this rectification, as ll others, the firſt products are the pureſt.

Characters.

itriolic ether is one of the lighteſt and moſt vo- e of all denſe and unelaſtic fluids. Its diſſipation the air is ſo ſudden as to produce an extreme ree of cold. It is highly inflammable, and burns a more luminous flame, and emits more ſmoke ardent ſpirit.

Solubility in water.

bout ten times its weight of water is ſufficient iſſolve it. A ſmall proportion of water renders ctified ether more pure, becauſe it combines with ardent ſpirit and acid it may contain; but there aſon to think, on the other hand, that the ether lves, and combines with part of the water.

Little

Combinations of vitriolic ether.

Little is known of the action of this fluid upon ſaline ſubſtances. Lime and fixed alkalis do not ſeem capable of uniting with it. Cauſtic volatile alkali combines with it in all proportions; vitriolic acid unites with it, and extricates heat, and from this combination ſweet oil of wine may be obtained by diſtillation. Nitrous acid efferveſces with ether, and renders it more oily. It diſſolves camphor very plentifully.

Method of preparing nitrous ether.

The nitrous acid acts very rapidly and powerfully upon ardent ſpirit, with which it forms a combination, poſſeſſing properties ſimilar to thoſe of the vitriolic ether. The combination takes place without the aſſiſtance of heat, and with ſuch facility, that it is even neceſſary to add the acid by degrees, and to uſe management for the purpoſe of preventing an exploſion, which might ariſe from the heat generated by the mixture. For this purpoſe ſix ounces of highly rectified ſpirit of wine are put into a bottle capable of containing a pound of water, and immerſed in a tub of very cold water, in which it will be advantageous to put three or four pounds of ice broken ſmall. Upon the ſpirit in this ſituation, and kept continually agitated, four ounces of ſpirit of nitre, of the ſpecific gravity of 1.5, are to be poured, in four or five ſucceſſive portions. As ſoon as the mixture is completed, the bottle muſt be cloſed with a good cork, ſecured with leather and packthread, or wire; and the whol muſt be left in a place where it may remain undiſturbed; no other attention being neceſſary than that of renewing the water, from time to time, as it ma become heated. In the courſe of two or three hour th

Methods of preparing nitrous ether.

tranſparency of the fluid becomes troubled, by an nity of drops of ether, which are diſengaged from ry part of its volume. This ether gradually riſes to ſurface; and at the end of twenty-four hours it y be ſeparated from the reſt of the liquor by means a funnel. In opening the phial, it is neceſſary firſt ierce the cork with a pointed inſtrument, in order t a quantity of elaſtic fluid may eſcape, which might erwiſe ſuddenly follow the cork, and carry part of fluid along with it. The quantity of ether ob- ıed in this manner will be about four ounces.

Characters.

Nitrous ether in this ſtate reſembles vitriolic ether ts ſmell, but it is ſtronger and leſs agreeable. Its our is a light orange; and a portion of the fluid s the elaſtic form, and eſcapes with efferveſcence never the bottle, which contains it, is opened. s ether appears to contain a portion of uncombined ., upon which theſe phenomena probably depend. uſt be rectified with a ſmall addition of alkali, ing which operation it loſes near half its weight. rectified nitrous ether burns with a flame rather e luminous than that of vitriolic ether, at the e time that it affords a ſomewhat larger portion ſmoke, and leaves a black trace behind it. In r reſpects it ſeems nearly to reſemble the vitriolic r.

Nitrous ether may be made with leſs danger, if acid be diluted, and the quantity of ſpirit duly ortioned. It may alſo be had by diſtillation of a ture of the two fluids, in the ſame manner as the olic ether; but in this caſe it is requiſite that the iving veſſels ſhould be uncommonly large, and

that

Methods of preparing nitrous ether.

that every precaution ſhould be taken to prevent their flying in pieces by the force of the elaſtic product which eſcapes: and, upon the whole, it does not ſeem probable that any ordinary degree of precaution would be ſufficient to inſure the operator from danger in this diſtillation. One very eſſential circumſtance conſiſts in uſing the acid in a diluted ſtate.—Nitrous ether has alſo been made by leſs direct proceſſes. If a due proportion of nitre and vitriolic acid be ſucceſſively put into a tubulated retort, the nitrous acid begins to be diſengaged; and, if ſpirit of wine be added to this mixture, nitrous ether comes over. Some degree of precaution is neceſſary in this proceſs; and it might be doubted whether part of the ether which comes over might not have been formed by the vitriolic acid, if moſt of the difficulties were not removed by the uſe of the apparatus, fig. 22. If the tube E be immerſed in a bottle containing highly rectified ſpirit of wine, and the nitrous acid be diſtilled from a quantity of nitre equal in weight to twice the ſpirit of wine, together with as much concentrated vitriolic acid as is equal to half the weight of the nitre; the firſt receiver D will, at the end of the operation, contain fuming nitrous acid; the remote bottle E wil contain an ethereal liquor; and the reſidue will b vitriolated tartar. The ethereal ſpirit of wine ma then be diſtilled, and the firſt two-thirds of the product reſerved. This reſerved product muſt be diſtille with one-fifth of its weight of ſmoking nitrous acid added by degrees to the liquor, in a tubulated retort by means of a long-necked funnel. Two thirds o this product only are to be taken; which, being rect

Nitrous ether.

from pot-aſh, afford at firſt a quantity of very e nitrous ether, equal to about one twelfth of the it made uſe of; and three fourths of the reſt being illed over, conſiſt of a leſs perfect ether, or mine- anodyne liquor. The reſidues of the diſtillations ſiſt of dulcified ſpirit of nitre *.

t is proper, even here, to take notice that all mix- s of the nitrous acid and ardent ſpirit require to made very gradually, and with great caution, for of exploſions.

he reſidue, after diſtillation of nitrous ether, is d, in ſome proportions of the materials and ma- ement of the proceſs, to contain no nitrous acid, an imperfect vinegar, and the acid of ſugar or el.

Method of preparing marine ether.

he marine acid cannot be combined with ſpirit of in the direct way. There are many indirect ods, which conſiſt in applying the dephlogiſticat- r aërated marine acid to ardent ſpirit. If to four es of common ſalt, and two ounces of pulverized ganeſe, there be added two ounces of concentrated olic acid, and ſix ounces of the pureſt ardent ſpi- and the whole be expoſed to diſtillation by a gentle , the marine acid will firſt riſe, ſomewhat changed; after a conſiderable portion has paſſed over, it muſt oured back upon the reſiduum, and diſtilled afreſh. his diſtillation, nearly the half which firſt comes will be dulcified ſpirit of ſalt; and the greateſt of the other half, marine ether, which may be ated from the reſt by the addition of water.

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* De la Planche, quoted by Fourcroy, iv. 252.

Marine ether is very tranſparent and volatile, and has nearly the ſame ſmell as the vitriolic ether. It burns like that fluid, and affords a ſmoke, with a ſuffocating ſmell.

Methods of preparing acetous ether.

It is doubted whether any ethereal fluid can be obtained by the direct union of acetous acid and ardent ſpirit. If equal parts of the ſtrongeſt acetous acid and ardent ſpirit be mixed together, and kept for ſome days in a well-ſtopped glaſs, and the mixture be then expoſed to diſtillation by a gentle heat, the firſt half which comes over will, it is ſaid, conſiſt of an ethereal fluid, from which the ether may be ſeparated, by the addition of a ſixteenth part of vegetable alkali, diſſolved in four times its quantity of water. The ether immediately riſes to the top, and commonly amounts to one half of the quantity of the ardent ſpirit made uſe of. To the vinegar that remains in the retort half the quantity of ardent ſpirit may be added, by which ſtill more of the ether may be obtained. The moſt certain and incontrovertible method, however, appears to conſiſt in forming the union between the ſpirit and acid by indirect means. This may be done by decompoſing ſome acetous ſalt, by the addition of a mineral acid, while ardent ſpirit is preſent. Thus, if an ounce of alkali ſaturated with vinegar be diſſolved in three ounces of ſpirit of wine, and a little more of any mineral acid than is ſufficient to ſaturate the alkali be added, and the maſs be then diſtilled, acetous ether will be obtained. Or if eight ounce of ſugar of lead be gently dried, to deprive it of it water of cryſtallization, which amounts to rather mor than one fourth of its weight; if in this ſtate it b

Acetous ether.

t into a glaſs retort, and a mixture of five ounces vitriolic acid, and eight ounces of ſpirit of wine, poured on it, and the whole expoſed to diſtillation a very gentle heat, the firſt ounce that paſſes over ll conſiſt of dulcified acetous acid, the next ounce ll be almoſt all ether, and the whole quantity of ether oduced will be near four ounces.

Acetous ether is not nearly ſo volatile as the nitrous vitriolic; it burns with a blue flame, like ſpirit of ne.

Ligneous ether.

The empyreumatic acid of wood likewiſe affords ether. For this purpoſe it may be diſtilled from ech, rectified a ſecond time, and then ſaturated with ali. Three pounds of the acid require about five nces of alkaline ſalt. By evaporation to dryneſs, th ſubſequent ſolution, filtration, and evaporation, ree ounces and a quarter of neutral ſalt are ob- ned. The concentrated acid of wood may be engaged from this by diſtillation with two ounces vitriolic acid; and the quantity of acid of wood is obtained weighs an ounce and three quarters. mixing this with an equal quantity of pure ardent rit, and diſtilling it in a ſmall retort, near two nces and a quarter of ether are obtained.

Saccharine ether.

Equal parts of ſalt of ſorrel and ardent ſpirit afford out one fifth of their weight of ether. The acid ſugar likewiſe affords an ether with ſpirit of wine, ich can hardly be ſuppoſed to differ from the fore- ing, as the two ſalts are the ſame.

Phoſphoric ether.

The acid of phoſphorus does not produce an ethe- l combination by direct diſtillation with ardent rit: but it is ſaid that the combination takes place with

ETHER.

with a due mixture of ardent ſpirit, vitriolic acid, and microcoſmic ſalt; the phoſphoric acid being expelled from its baſe, probably in a more dephlogiſticated ſtate than when obtained by ſuffering phoſphorus to deliqueſce in the air.

Ether produced by acid of ants:

The acid of ants produces an ether, with ſpirit of wine, by ſimilar treatment.

— by acid of benzoin.

Acid of benzoin does not produce ether by ſimple ſolution, and ſtanding in ſpirit of wine; but, when one part of the acid of benzoin is diſtilled with three parts of ardent ſpirit, and one half part of common marine acid, the pure ſpirit comes firſt over, and afterwards an ethereal combination, one part of which floats upon water, and the other ſinks to the bottom. This is not more volatile than acetous ether, and burns with a bright flame and ſmoke.

General obſervations.

The converſion of ardent ſpirit into ether, is a proceſs concerning which much remains to be explained. It was formerly thought that the acid did nothing more than deprive the ſpirit of a quantity of water, which was before combined with it, and prevented its exhibiting oleaginous properties. It ſeems aſcertained however, at preſent, that all the ethers contain a portion of that peculiar acid, by whoſe action the ſpirit was changed; as may be ſhewn by ſuffering them to evaporate, or burning them away upon water. It appears therefore that the acid, or ſome of its component parts, combine either with the whole or part of the ardent ſpirit. Some chemiſts have with conſiderable probability aſſerted, that the baſis, or acidifiable principle, of the acid, combines with the ſpirit by the effect of a double affinity; ſo

that

ETHER.

Theoretical obſervations.

the vital air of the acid combines with a portion
cetous baſis exiſting in the ſpirit, and forms vi-
ır; another portion combines with the vegetable
ciples exiſting in ſuch a ſtate as to form the ſaccha-
acid; and, laſtly, the acidifiable baſis itſelf, which
out this vital air, is ſuppoſed to combine with
undecompoſed ſpirit, or vegetable inflammable
er, and riſe in the form of ether. In this view
he ſubject, the nitrous ether is more particularly
nded to, and the inferences are extended to other
rs; and oils are ſuppoſed to conſiſt of vegetable
mmable matter, combined with the baſis of an
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On Ethers, ſee Wiegleb's Chemiſtry, by Hopſon, p. 510, et
Scheele's Eſſays, &c.

CHAP. X.

CONCERNING THE ACETOUS ACID.

ACETOUS ACID.

As moſt of the compounded vegetable acids are convertible, by nitrous acid and by other means, into acid of ſugar, and this laſt into vinegar, it is evident that fermentation is only one of the proceſſes which change the principles of plants into this leaſt deſtructible of vegetable acids. All the vinegar however which is uſed in the common purpoſes of life, is obtained by fermentation. Crude vinegar contains not only that peculiar acid which is diſtinguiſhed by the name of acetous, but likewiſe tartar, oily matter, and frequently ſome of the acids of the fruits from which it may have been procured. It is uſual to purify it by diſtillation. The firſt product conſiſts of a watery fluid, of a lively and agreeable ſmell, though ſcarcely acid. Next follows the acetous acid, commonly called diſtilled vinegar, which has a peculiar ſmell, leſs agreeable than that of the crude vinegar. As the diſtillation proceeds, the volatile product becomes more and more acid, ſomewhat darker coloured, and of an empyreumatic ſmell. The reſidue, after the greateſt part of the fluid has been volatilized, has a deep browniſh red colour, is conſiderably acid, and depoſits a quantity of tartar. By diſtillation to dryneſs, it affords a reddiſh phlegm; more acid; an oil, at firſt light, and afterwards heavy; together with a ſmall quantity of volatile alkali: the reſidual coal contains

Crude vinegar.

Diſtilled vinegar, or acetous acid.

tains much fixed alkali. The quantity of acid product reſerved as diſtilled vinegar, is commonly about two thirds of the whole.

Concentration of vinegar by froſt.

Vinegar may be concentrated by froſt, which ſeparates its aqueous part. This proceſs is particularly applicable to crude vinegar; as, by this means, the grateful flavour, and peculiar properties, are preſerved. An ingenious method has been contrived for combining the two proceſſes of diſtillation and congelation, in concentrating and purifying vinegar. In this way, good wine vinegar is to be diſtilled on a water bath. It is eſſential to reſerve the phlegm, becauſe the moſt fragrant parts come over firſt, and are retained in this fluid. The diſtilled vinegar and phlegm being then expoſed to a freezing cold, and the ice taken out, a concentrated acid remains; which may be completely deprived of its extraneous and oily parts, by repeated rectifications on a water bath. At the beginning of the rectification, a very ſpirituous fluid paſſes over; which being ſeparated, and rectified by itſelf, yields a true and fine ether, of a very pleaſant ſmell, and immiſcible with water; which ether is to be added to the ſtrong and purified vinegar obtained by the repeated rectifications. The author of this method obſerves, that the peculiar and unpleaſant ſmell of diſtilled vinegar proceeds from ſome oily parts which paſs over in the diſtillation; and that, when theſe parts have been ſeparated by rectifying the acid concentrated by froſt, it again recovers the pleaſant ſmell of undiſtilled vinegar *.

The moſt advantageous method of concentrating vinegar.

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* Lowitz, in Crell's *Annals*, quoted by Keir in his Chemical Dictionary, page 37.

ACETOUS ACID.

Combinations of acetous acid:

Pure acetous acid enters into many combinations; and is recovered again by decompoſition, though ſeldom perhaps in its original ſtate. In many of its combinations it ſeems neceſſary that it ſhould become more ſtrongly acidified by attracting vital air from the atmoſphere, or from other bodies. This circumſtance has not been ſufficiently attended to, to admit of a proper diſtinction of every caſe in which it may, or may not, happen. We ſhall not therefore attempt to point them out, except incidentally, and where the facts are clear.

—with argillaceous earth:

The acetous acid unites with earth of alum, or argillaceous earth, in conſiderable quantity, and forms a whitiſh ſaline maſs, which is not cryſtallizable. There is however a diſagreement among practical chemiſts reſpecting this combination. Some aſſert that it takes place very ſparingly, and forms ſmall needled cryſtals. Theſe differences may probably depend on certain circumſtances relative to the edulcoration of the earth of alum, after it has been precipitated from its ſolution by an alkali.

—with calcareous earth:

Calcareous earth is readily diſſolved in the acetous acid, and forms a ſalt, the figure of whoſe cryſtals varies according to circumſtances. It is permanent in the air, unleſs the acid be in exceſs; in which caſe it deliqueſces. Its taſte is ſharp and bitter. When diſtilled without addition, the acid quits the earth, and appears in the form of an inflammable vapour, which condenſes into a reddiſh brown liquor; and, when rectified, is very volatile and inflammable.

The acetous acid forms a ſaline maſs by combination n with ponderous earth, which does not cryſtallize, t, if dried, attracts moiſture from the air.

Combination of acetous acid with magneſia:

Magneſian earth unites with acetous acid, and ords a very ſoluble ſalt; which, when perfectly turated and evaporated, affords a viſcid maſs, reſem-ing gum water. Its taſte is ſweetiſh at firſt, but terwards bitter; and it is ſoluble in ſpirit of wine. ere heat diſſipates its acid, which may be obtained diſtillation.

— with vegetable alkali. Foliated earth of tartar.

The combination of vegetable alkali with the ace-us acid, produces the ſalt improperly called foliated rth of tartar. In the preparation of this ſalt, it is ſt to add an exceſs of acid. The evaporation muſt carried to dryneſs on a water bath, in a glaſs or ver veſſel. This ſalt cannot eaſily be cryſtallized. taſte is penetrating, acrid, and urinous; heat de-mpoſes it: by diſtillation, it affords an acid phlegm, npyreumatic oil, volatile alkali, and much elaſtic id, conſiſting of fixed and inflammable air. The ſidual coal contains much vegetable alkali. If foli-ed tartar be decompoſed by the addition of vitriolic id in diſtillation, the quantities being one part of e concentrated acid to two of the ſalt, in a tubu-ed retort, with a receiver, or apparatus of veſſels apted, the acetous acid immediately riſes in the ſtic form, with a ſtrong efferveſcence, and is con-nſed in the receiver. This fluid is called radical negar, and its acid properties are more intenſe than oſe of common acetous acid. It is highly probable at this augmentation of acidity is produced by the nſition of vital air from the vitriolic acid to the etous; perhaps with the contrary tranſition of phlo-

Radical vinegar.

Combinations of acetous acid:

giſton. So that, while the acetous acid becomes more acidified, a portion of the vitriolic acid has its acidity diminiſhed, and is converted into ſulphureous acid, which comes over, and contaminates the product in the receiver.

— with mineral alkali:

The acetous acid unites perfectly with the mineral alkali, and forms a cryſtallizable permanent ſalt. The properties of the acetous ſalt of mineral alkali do not remarkably differ from thoſe of the foliated earth of tartar. By diſtillation with vitriolic acid, it affords a purer acetous acid than the foliated tartar does.

— with volatile alkali:

The ſalt formed by uniting acetous acid with volatile alkali, has been called ſpirit of Mindererus, or acetous ſal ammoniac. It does not eaſily cryſtallize; for which purpoſe it requires to be evaporated to the conſiſtence of ſyrup, and then expoſed to the cold. It ſoon attracts the moiſture of the air, and has a ſharp and burning taſte. This ſalt is decompoſable by heat; by lime and alkalis, which ſeize its acid; or by the mineral acids, which ſeize its baſe.

— with gold:

The acetous acid has no effect on gold in the metallic ſtate. When added to a ſolution of gold, it throws it down in the metalline form. The precipitate of gold, effected by a fixed alkali, becomes of a purple colour when digeſted with the common acetous acid. Radical vinegar diſſolves it.

— with ſilver.

Silver is not acted on by acetous acid; though the calces of this metal, obtained by an alkali from nitrous acid, are ſoluble.

Platina is likewiſe inſoluble in this acid; though its precipitate from aqua regia, by a fixed alkali, is ſoluble.

Acetous

ACETOUS ACID.

Combination of acetous acid with mercury:

Acetous acid does not appear to be affected by rcury; but it diſſolves the mercurial calces. The ſtals of this ſolution have a foliated appearance, embling that of the acid of borax.

—with lead:

Page 270.

Lead is diſſolved with the greateſt facility by vine- . The manufacture of ceruſe and ſugar of lead before engaged our attention.

—with copper:

Copper is likewiſe ſoluble in vinegar, provided at- ſpheric air be preſent. The cryſtals of acetous acid d copper are improperly called diſtilled verdigriſe. is from this ſalt that radical vinegar has uſually been tilled by mere heat, without addition. It is at firſt oured by a portion of copper, which comes over; which reaſon it muſt be rectified by a gentle heat. e reſidue, after diſtilling the acetous ſalt of copper, ſiſts of the metal in its reguline ſtate; whence it ſeen that the vital air required to calcine the cop- , comes over with the acid, which conſequently is a dephlogiſticated or aërated ſtate. The laſt por- n of radical acid which comes over is inflammable, d congealable by cold.

— with iron.

Iron is readily diſſolved by the acetous acid, with light effervеſcence, and the diſengagement of in- mmable air. This ſolution depoſits much calx of n by evaporation; and yields a few deliqueſcent ſtals when cool. Very little action takes place ween common vinegar and iron filings, unleſs ſtanding; during which time, it is probable that action of the air may contribute in ſome degree to effect.

Compare page 309.

— with tin.

When tin is digeſted with the acetous acid, a ſmall rtion appears to be taken up. The acid becomes turbid, acquires a metallic taſte, and affords a ſmall quantity of precipitate by alkalis.

Metallic combinations.

Biſmuth and its calx are ſoluble in this acid, though ſparingly. Nickel is diſſolved, and the ſolution affords green cryſtals. Regulus of arſenic is inſoluble, but its calx is taken up. The regulus of cobalt is likewiſe inſoluble; its calx affords a pale roſe-coloured ſolution, which is a ſympathetic ink, and receives a green colour from marine acid. Zinc is ſoluble not only in its metallic and calciform ſtates, but alſo, as it is ſaid, when mixed with other metals: hence it ſhould ſeem ill calculated to defend copper veſſels from the action of this vegetable acid. The ſolution of zinc in common acetous acid affords plated cryſtals. Regulus of antimony is very ſparingly acted on by the acetous acid; inſomuch that it might be judged that no action took place, if it did not impart an emetic quality to the fluid. Manganeſe is not acted on by this acid but with great difficulty, though repeated diſtillations at length combine the two ſubſtances. It has not been aſcertained whether the acetous acid has any action upon wolfram or molybdena.

Zinc an improper material to defend copper veſſels.

BOOK

BOOK II.

ARTICULAR CHEMISTRY.

SECTION VI.

CONCERNING THE PRODUCTS OF THE ANIMAL KINGDOM.

CHAP. I.

A SHORT ENUMERATION OF SUCH ANIMAL SUBSTANCES AS HAVE BEEN EXAMINED BY CHEMISTS.

ANIMAL SUBSTANCES.
Analyſis and arrangement.
Page 411—415.

THE general ſtructure and methods of analyſing animal ſubſtances have been already noticed. therefore remains only to enumerate and deſcribe e ſeveral products of this kingdom, which have en- aged the attention of chemiſts. In the arrangement f theſe, as in the vegetable kingdom, we cannot, on count of the imperfect ſtate of our knowledge, have courſe to the nature of their component parts; but

Enumeration.

ſhall rather attend to the means by which they are reſpectively afforded or obtained. In this way we may conſider the parts of animals as either,

1. Such as are uſually obtained without deſtroying life. Theſe are milk, eggs, urine, excrement, the matter of perſpiration, ambergris, &c.; wax, honey, gum lac, ſilk, hair, horn, feathers, &c. Or,

2. Such parts of animals as are obtained by deſtroying them, or depriving them of life. Theſe are blood; various ſolids, confounded under the name of fleſh, fat, ſpermaceti; bile, the gaſtric juice, and ſeveral acids; together with calcareous earth, and other ſubſtances, common to the mineral and vegetable kingdoms.

CHAP. II.

NCERNING MILK, EGGS, HONEY, WAX, LACCA, SILK, HAIR, HORN, ETC.

MILK.

General characters of milk.

MILK is a well-known fluid, ſecreted in peculiar veſſels of the females of the human ſpecies, of ıdrupeds, and of cetaceous animals, and deſtined for purpoſe of nouriſhing their young. Its appearance l component parts are not altogether the ſame in ious ſpecies of animals; but the differences have yet been well aſcertained. For this reaſon, in ating of milk, our attention will be confined to that the cow, becauſe the moſt abundantly met with. is fluid is of a beautiful opake white colour, nearly limpid as water, and of a pleaſant emulſive taſte. appearance on the ſtage of a microſcope exhibits infinity of minute opake globules floating in a nſparent fluid.

Effects of heat on cows milk.

Cows milk, diſtilled on a water bath, affords a teleſs phlegm of a faint ſmell, which is capable putrefying. A ſtronger heat coagulates it. It is netimes gradually dried into a ſubſtance which is kind of ſaccharine extract, and may again be difſed in water. By deſtructive diſtillation, milk ords an acid, a fluid oil, a concrete oil, and volatile ali. Its reſidual coal contains a ſmall quantity of getable alkali, ſome ſalt of Sylvius, and phoſphoric lcareous ſalt.

When

MILK.

Fermentation of milk.

Page 465.

When milk is left to ſpontaneous decompoſition, at a due temperature, it is found to be capable of paſſing through the vinous, acetous, and putrefactive fermentations. It appears however, probably on account of the ſmall quantity of ardent ſpirit it contains, that the vinous fermentation laſts a very ſhort time, and can ſcarcely be made to take place in every part of the fluid at once by the addition of any ferment. This ſeems to be the reaſon why the Tartars, who make a fermented wine from mares milk, called koumiſs, ſucceed by uſing large quantities at a time, and agitating it very frequently.

Cream.

Butter.

Acid of milk.

When milk is left expoſed for ſome hours in a ſtate of repoſe, a ſmall quantity of thick fluid riſes to the top, and is known by the name of cream. This contains the fat ſubſtance called butter, which is afterwards ſeparated from it by agitation in the act of churning. The remainder afterwards becomes ſour, and undergoes a coagulation which ſeparates it into two parts—a ſolid curd; and a fluid, called ſerum or whey. This ſour whey contains a peculiar acid, called the acid of milk, and likewiſe a portion of vinegar. The peculiar acid does not riſe in diſtillation, but may be ſeparated by evaporating the filtered whey to one eighth; and precipitating the phoſphoric ſalt by the addition of lime-water, which fully ſaturates its acid: the fluid is then to be diluted with three times its weight of water; and the redundant lime precipitated by ſaccharine acid, in which operation the exceſs of the laſt-mentioned acid may be guarded againſt by the teſt of a ſmall portion of lime-water. This purified liquor muſt then be evaporated to the conſiſtence

Acid of milk.

nce of honey; and the other foreign ſubſtances
ay contain will be ſeparated by the addition
ure ardent ſpirit, which takes up the acid of
only. The decanted ſolution being then diluted
water, and heated, the ardent ſpirit flies off,
leaves the acid of milk behind, diſſolved in the
r.

Combinations with various ſubſtances.

his acid does not afford cryſtals; and, when eva-
ted to dryneſs, it deliqueſces again by expoſure
ir. With vegetable alkali it affords a deliqueſ-
ſalt, ſoluble in ardent ſpirit. With mineral al-
it affords a ſalt poſſeſſing the ſame properties.
h volatile alkali it produces a deliqueſcent ſalt,
h yields much of its alkali by diſtillation before
acid is deſtroyed by heat. With lime, clay, and
lerous earth, it forms deliqueſcent ſalts; but with
neſia it affords ſmall cryſtals, which at length deli-
ce. The acid of milk diſſolves iron and zinc, and
uces inflammable air. Copper affords a dark blue
ion, which does not cryſtallize. Lead is diſſolved
ſome days digeſtion, and affords veſtiges of vitri-
acid. Biſmuth, cobalt, antimony, tin, mercury,
r, and gold, are not affected by this acid in a
ſtive or boiling heat. Deſtructive diſtillation de-
poſes the acid of milk: water firſt comes over;
a weak acid, reſembling the empyreumatic acid
artar; afterwards ſome empyreumatic oil, with
of the ſame acid, and alſo fixed air, and
heavy inflammable air. A coal remains in the
t.

Curd.

any vegetable or mineral acid be added to milk,
urd is ſeparated, and coagulates into one maſs, if
the

Curd.

the mixture be aſſiſted by the application of heat. The curd obtained by means of mineral acid, always manifeſts ſigns of acidity, and is partially ſoluble in boiling water. If any neutral, earthy, or metallic ſalt be added to ſaturation in milk, it likewiſe ſeparates the curd. Sugar and gum-arabic produce a ſimilar effect. Cauſtic alkalis diſſolve the curd, by the aſſiſtance of a boiling heat; and it may again be coagulated by the addition of acids.

Manufacture of cheeſe:

The coagulation of milk, in the manufacture of cheeſe, is effected by the addition of rennet, which is the infuſion of the ſtomach of a ſucking calf in water, prepared in various ways, according to the fancy of the makers. This fluid ſeems to owe its properties to the gaſtric juice of the animal. The ſeparated curd is wrapped in a cloth with ſalt, and preſſed, to deprive it of the ſuperfluous whey; after which, it is preſerved for ſeveral months or years before it is conſidered as fit for uſe.

— properties.

Cheeſe, when decompoſed by deſtructive diſtillation, affords an alkaline phlegm, an heavy oil, and much volatile alkali. Its reſidual coal is difficult to incinerate, and does not afford fixed alkali. By treating it with the nitrous acid, it is found to contain lime and phoſphoric acid. Cheeſe is not ſoluble in water. Hot water hardens it.

Sugar of milk.

The ſaccharine ſubſtance, upon which the fermenting property of milk depends, is held in ſolution by the whey which remains after the ſeparation of the curd in making cheeſe. This is ſeparated by evaporation in the large way, for pharmaceutical purpoſes, in various parts of Switzerland. When the whey ha

bee

Sugar of milk:

een evaporated by heat, to the conſiſtence of honey, is poured into proper moulds, and expoſed to dry in he ſun. If this crude ſugar of milk be diſſolved in vater, clarified with whites of eggs, and evaporated to he conſiſtence of ſyrup, white cryſtals, in the form of homboidal parallelopipedons, are obtained.

— Decompoſition by heat:

Sugar of milk has a faint ſaccharine taſte, and is oluble in three or four parts of water. It yields by iſtillation the very ſame products that other ſugars o. It is remarkable, however, that the empyreumatic il has a ſmell reſembling flowers of benzoin. Twelve unces of diluted nitrous acid being poured upon four unces of finely powdered ſugar of milk, in a glaſs etort, on a ſand-bath, with a receiver annexed, the nixture became gradually hot, and at length effer-eſced violently, and continued to do ſo for a conſi-erable time after the retort was taken from the fire. t is neceſſary therefore, in making the experiment, to ſe a large retort, and not to lute the receiver too tight o the retort. After the efferveſcence had in ſome neaſure ſubſided, the retort was again placed on the and-bath, and the nitrous acid diſtilled off, till the naſs acquired a yellowiſh colour. This yellow fluid xhibited no cryſtals. Eight ounces more of the ſame itrous acid were therefore added, and the diſtillation gain repeated, till the yellow colour of the fluid diſ-ppeared. The fluid became inſpiſſated by cooling; it vas therefore rediſſolved in eight ounces of water, and iltered. Seven drams and a half of a white powder emained on the filter, and the clear ſolution afforded ryſtals of ſaccharine acid. The mother water was gain treated ſeveral times with nitrous acid, by which

— treatment with nitrous acid.

which means the whole was at length changed into ſaccharine acid.

Peculiar acid of ſugar of milk.

The white powder that remained on the filter was found to be combuſtible like oil in a red hot crucible, without leaving any mark of aſhes behind. It was ſoluble in ſixty times its weight of boiling water; and one fourth part ſeparated by cooling, in the form of very ſmall cryſtals. The remaining maſs being then collected, by evaporating the greateſt part of the water, left behind a ſmall portion of the acid of ſugar, of which it had not been ſo exactly deprived by edulcoration on the filter. From theſe circumſtances it appeared that the white matter was a ſalt; and, upon examination, it was found to be an acid, poſſeſſing the following properties:

Combinations.

With all the ſoluble earths it forms ſalts inſoluble in water. It diſengages fixed air from the mild alkalis. With vegetable alkali it forms a cryſtallizable ſalt, ſoluble in eight times its quantity of boiling water, and ſeparable for the moſt part by cooling. With the mineral alkali it forms a ſalt which requires only five parts of boiling water for its ſolution. Both theſe ſalts are perfectly neutral. When ſaturated with volatile alkali, it forms a ſalt which, after being gently dried, has a ſouriſh taſte. It does not perceptibly act on the metals; but forms with their calces, in ſolution, ſalts of very difficult ſolubility, which are therefore precipitated *.

The principles of milk appear to be united together partly in a chemical, and partly in a mechanical manner;

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* On milk and its acid, and on the acid of the ſugar of milk, conſult the Chemical Eſſays of Scheele.

anner; and the butter ſeems to riſe to the top in
nſequence of the greater ſpecific gravity of the
hey through which it is diſperſed. Cream conſiſts

Separation of butter from cream:

butter mixed with much whey and curd. It is
nerally thought that the ſeparation of the butter by
urning is effected ſimply by the agitation, which
uſes the fatty particles to ſtrike againſt each other,
d coagulate into larger maſſes. There ſeems how-
er ſome reaſon to think that a chemical effect takes
ce in this operation; in which the intimate mix-
re of atmoſpheric air with the fluid may perhaps
ve ſome effect.

—its properties.

Butter appears to be of the nature of fat oils; but
conſidered by moſt nations as infinitely preferable
them, as an article of food. By diſtillation on a
ter-bath it gives out the aqueous fluid which, from
manner of its fabrication, is diſtributed through
maſs. Its products, by deſtructive diſtillation,
rly reſemble thoſe of other oils. They conſiſt of
acid of a ſtrong and penetrating ſmell, a fluid oil,
a concrete oil of the ſame ſmell as the acid.
eſe oils, like others obtained in ſimilar circum-
nces, may, by repeated rectifications, be converted
o volatile oils, of the nature of thoſe which are
led eſſential. In other reſpects, butter poſſeſſes the
e properties, and may be applied to the ſame uſes
fat oils. It becomes rancid by ſpontaneous decom-
ition, which developes its acid; and with fixed
alis it forms ſoap.

Eggs.

The eggs of birds conſiderably reſemble milk in
ir component parts, though their peculiar ſtructure

and organization conſtitute a great and eſſential difference, applicable to the purpoſes of generation, into which our preſent views do not require us to proceed. The white of egg does not greatly differ from the curd of milk or cheeſe. When it is mixed with water, it forms a coagulum or curd by the addition of acids. Heat coagulates the white of egg, without depriving it of weight; which is a very ſingular fact, and has not yet been well explained. The white of egg however appears to differ, in ſome reſpects, from curd. It is ſaid to afford a ſmall portion of ſulphur by ſublimation; and it contains the mineral alkali in a diſengaged ſtate.

Reſemblance between white of egg and curd of milk.

Yolk of egg.

The yolk of egg appears to be an animal emulſion, which is diffuſible in water. It contains an oil, which may be ſeparated by drying, and afterwards ſubjecting it to preſſure.

Honey and wax.

Honey and wax may be conſidered as animal ſubſtances, becauſe afforded by the bee; though it is not improbable but theſe laborious inſects may extract them from the veſſels of plants, and depoſit them in their hives without alteration.

Purification of honey.

Honey which is purified by ſolution and cryſtallization, perfectly reſembles the ſaccharine juices of vegetables which have undergone the like treatment. It affords the ſame product as ſugar by deſtructive diſtillation. Nitrous acid converts it into the ſaccharine acid, and its aqueous ſolution is ſuſceptible of all the ſtages of fermentation. It is accordingly, as we have before obſerved, made uſe of in the preparation of a vinous liquor.

Page 465.

Diſtillation of wax.

Wax is a concrete ſubſtance, which greatly reſembles the more ſolid fixed oils, and unites with oily ſubſtances in all proportions. Its products, by deſtructive diſtillation, are the ſame as thoſe of other fat ſubſtances. The concreſcible oil obtained by diſtillation of this ſubſtance, is called butter of wax. Bees-wax is of a yellow colour, but becomes white by expoſure to air: this effect takes place only at or near the ſurface or place of contact; for which reaſon the bleachers of wax find it neceſſary to renew the ſurface frequently. This is done either by cauſing the melted wax to paſs through a number of holes in the bottom of a veſſel into another veſſel of water, by which means it undergoes that kind of diviſion which, in metallic bodies, is called granulation; or it is gently poured upon a wooden cylinder, which is turned round in a veſſel filled with water to ſuch a height, that half of the cylinder is immerſed. In this way, the wax forms a number of thin flakes, that do not adhere to each other, but may be taken off, and expoſed to the action of the air. The dephlogiſticated or aërated marine acid bleaches wax very ſpeedily; from which fact it appears that the wax owes its whiteneſs, and the greater conſiſtency it acquires, to an abſorption of the vital part of the atmoſphere. Wax ſeems to differ from tallow, or concrete oil, principally in this circumſtance: and this laſt ſubſtance becomes likewiſe harder and whiter by long expoſure to the air, in thin maſſes; as, for example, when it is ſpread out upon the ſurface of water. Wax being already combined with a portion of vital air, does not burn with ſo luminous a flame as tallow or oil. But it poſſeſſes a very great

Butter of wax.

Bleaching.

Difference between wax and tallow.

great advantage in the fabrication of candles, which ariſes from the circumſtance of its freezing point being placed at a conſiderably higher temperature than thoſe of either of the other two ſubſtances.

An explanation of the chief advantage of wax candles compared with thoſe of tallow.

To explain this advantage, it muſt be conſidered, that oils do not take fire, unleſs they be previouſly volatilized by heat. The wick of a candle, or lamp, anſwers this purpoſe. The oil riſes between the fibres of the wick by the capillary attraction. Heat is applied to the extremity of the wick, which volatilizes and ſets fire to a portion of the oil. While this is diſſipated by combuſtion, another portion paſſes along the fibres, and ſupplies its place by becoming heated and burned likewiſe. In this way a conſtant combuſtion is maintained. It muſt be remarked, however, that a candle differs from a lamp in one very eſſential circumſtance, namely, that the oil, or tallow, is liquefied only as it comes to be in the vicinity of the conflagration; and this fluid is retained in the hollow of the part which is ſtill concrete, and forms a kind of cup. For this reaſon, it is found neceſſary that the wick ſhould not be too thin; becauſe, in this caſe, it would not carry off the fluid as faſt as it becomes fuſed; and the conſequence would be, that it would run down the ſides of the candle: and, as the inconvenience ariſes from the fuſibility of the oil, it is plain that a more fuſible candle will require a larger wick; or that the wick of a wax candle may be made thinner than that of one of tallow.

The difference of effect, in illumination, between a thick and a thin wick, cannot be better ſhewn than by remarking the appearances produced by both. When

The uſe and effects of the wick in candles.

a candle with a thick wick is firſt lighted, and the wick ſnuffed ſhort, the flame is perfect and luminous, unleſs its diameter be very great; in which laſt caſe, there is an opake part in the middle, where the combuſtion is impeded for want of air. As the wick becomes longer, the ſpace between its upper extremity and the apex of the flame is diminiſhed; and conſequently the oil which iſſues from that extremity, having a leſs ſpace of ignition to paſs through, is leſs completely burned, and paſſes off partly in ſmoke. This evil continues to increaſe, until at length the upper extremity of the wick projects beyond the flame, and forms a ſupport for an accumulation of ſoot, which is afforded by the imperfect combuſtion. A candle, in this ſituation, affords ſcarcely one tenth of the light which the due combuſtion of its materials would produce; and tallow-candles, on this account, require continual ſnuffing.—But, on the contrary, if we conſider the wax candle, we find that, as its wick lengthens, the light indeed becomes leſs, and the cup becomes filled with melted wax. The wick however, being thin and flexible, does not long occupy its place in the center of the flame; neither does it, when there, enlarge the diameter of the flame ſo as to prevent the acceſs of air to its internal part. When its length is too great for the vertical poſition, it bends on one ſide; and its extremity, coming into contact with the air, is burned to aſhes; excepting ſuch a portion as is defended by the continual afflux of melted wax, which is volatilized, and completely burned, by the ſurrounding flame. We ſee therefore that the difficult fuſibility of wax renders it practicable to burn a large quantity of

fluid

fluid by means of a ſmall wick; and that this ſmall wick, by turning on one ſide in conſequence of its flexibility, performs the operation of ſnuffing upon itſelf, in a much more accurate manner than it can ever be performed mechanically.

Wax is not ſoluble in ardent ſpirit.

Stick-lac, ſhell-lac, and ſeed-lac:

Lac, or lacca, is a ſubſtance well known in Europe, under the different appellations of ſtick-lac, ſhell-lac, and ſeed-lac. The firſt is the lac itſelf, which is a brown ſemi-tranſparent ſubſtance, in pretty conſiderable lumps, with woody parts adhering to it. Seed-lac is the ſtick-lac broken in pieces, and appearing in a granulated form. Shell-lac is the ſubſtance which has undergone a ſimple purification.

—its production.

Lac is the product of an inſect *, which depoſits its eggs on the branches of a tree called Bihar, in Aſſam, a country bordering on Thibet, and elſewhere in India. It appears deſigned to anſwer the purpoſe of defending the eggs from injury, and affording food for the maggot in a more advanced ſtate. It is formed into cells, finiſhed with as much art and regularity as an honey-comb, but differently arranged; and the inhabitants collect it twice a year, in the months of February and Auguſt. For the purification, it is broken into ſmall pieces, and put into a canvas bag of about four feet long, and not above ſix inches in circumference. Two of theſe bags are in conſtant uſe, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to paſs

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* For a deſcription, conſult Kerr, in the Phil. Tranſ. vol. lxxi. p. 374.

through its pores; when it is taken off the fire, and twiſted in different directions by the men who hold it, at the ſame time dragging it along the convex part of a plantain tree prepared for that purpoſe; and, while this is doing, the other bag is heating, to be treated in the ſame way. The mucilaginous and ſmooth ſurface of the plantain tree prevents its adhering; and the degree of preſſure regulates the thickneſs of the coating of lac, at the ſame time that the fineneſs of the bag determines its clearneſs and tranſparency *. Purification of lac.

Characters. Lac is not entitled to arrangement either with oils, reſins, or gums. It is not ſoluble either in water, or in fat oils. Some eſſential oils appear to extract a dilute tincture. The action of the acids upon lac, either when concentrated or diluted, does not ſeem to be conſiderable; but this requires more particular examination, eſpecially as far as relates to the nitrous acid. Ardent ſpirit acts but feebly on this ſubſtance. By ſtanding upon it in the cold, it forms a clear tincture, apparently by diſſolving only a part of its principles; but, when digeſted in a moderate heat, the whole of the lac unites with the ſpirit, and forms a turbid mixture, or imperfect ſolution, of a gummy appearance, which does not afterwards become clear. Hard varniſh. In this way, however, with judicious management, it appears practicable to form a very hard opake varniſh, reſembling that of China or Japan. The principal uſe of lac is in the manufacturing of ſealing-wax, and in dying ſcarlet. For this laſt purpoſe, half a dram of powdered comfrey root is to be boiled in a quart of

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* Saunders, in Phil. Tranſ. vol. lxxix.

Uſes of lac.

water for a quarter of an hour, and ſome powdered gum lac digeſted in the decoction for two hours. The tincture appears of a fine crimſon colour; and the remaining lac, if the quantity of liquor has been ſufficient, is of a pale ſtraw colour. The clear tincture being then poured off, and a ſolution of alum gradually added, the colouring matter ſubſides, in the form of one of the powders called lakes, which amounts to about one fifth part of the weight of the lac. This fecula is diſſolved in warm water, with the addition of a proper quantity of the ſolution of tin in aqua regia: and the liquor, which is of a fiery red colour, is then to be poured into boiling water, impregnated with ſalt of tartar, or the mild fixed vegetable alkali. The bath, thus formed, is a good ſcarlet dye for woollens, though leſs lively than that of cochineal.

Lewis on Neumann.

Silk, and the acid of ſilk-worms.

Silk is a well-known ſubſtance, which ſerves as a nidus for the chryſalis of the ſilk-worm. Its extenſive utility, when contraſted with the ſmall proſpect of advantage which its appearance in the crude ſtate ſeems to afford, may ſerve to ſtimulate our induſtry in the examination of other natural products; many of which, though neglected at preſent, might, on enquiry, be found equally beneficial to ſociety. This ſubſtance ſeems to hold a middle rank between animal and vegetable matters. It affords volatile alkali by diſtillation, and gives out phlogiſticated air when treated with nitrous acid. By diſtilling the nitrous acid from this ſubſtance, the acid of ſugar is obtained, and likewiſe a peculiar oil. The phalæna, or moth of the ſilk-worm, ejects a liquor which appears to contain

SILK. WOOL.

ontain a peculiar acid, hitherto little examined. It obtained in a ſtate of purity by infuſing the chryſa-des in ardent ſpirits, and ſubſequent evaporation.

Animal excreſcences.

The hair and wool of animals do not ſeem to differ reatly from ſilk. They afford much acid of ſugar, hen treated with nitrous acid. It is probable that orns, feathers, and other ſimilar excreſcences of ani-als, are nearly of the ſame nature.

CHAP. III.

CONCERNING THE EXCREMENTITIOUS PARTS OF ANIMALS.

EXCREMENTITIOUS MATTERS.

Urine and fecal matter.

Page 208.

THE ſubſtances which are rejected out of the bodies of animals, as uſeleſs, are urine, and the fecal matter, or excrement. Theſe differ in the various ſpecies of animals, according to their reſpective natures and food. But little attention has been paid by chemiſts to the urine or excrements of any animals except the human ſpecies. We have already had occaſion to mention the contents of urine, in treating of the phoſphoric acid, in our account of the mineral kingdom; and ſhall therefore, in the preſent place, confine our remarks to that peculiar depoſition which is known by the name of the urinary calculus, or ſtone of the bladder.

Stone of the bladder.

The matter which forms theſe hard concretions is found in all urine; and is depoſited by cooling, after the greateſt part is evaporated. Heat again diſſolves it. In about three hundred times its weight of boiling water it is either totally ſoluble, or it leaves a very inconſiderable reſidue, which ſeems to be an impurity. As the fluid becomes cold, moſt of the calculus is again ſeparated in fine cryſtals. The vitriolic acid diſſolves it with efferveſcence; the marine acid does not appear to act upon it; and the nitrous acid totally diſſolves it. This ſolution affords no precipitate by the acid of ſugar, though the vitriolic acid throws down a ſmall portion of ſelenite: whence it appears that the

EXCREMENTITIOUS MATTERS.

Acid of the ſtone of the bladder.

lculus contains ſome lime. Pure alkalis diſſolve it, does likewiſe lime-water. By deſtructive diſtilla-ɔn, the calculus affords fluid volatile alkali, and a ſub-nate of a brown colour, which by a ſecond ſublima-ɔn becomes white. This has a ſouriſh taſte, is eaſily luble in boiling water, and alſo in ardent ſpirit.

From the above, and other experiments, it appears at the calculus conſiſts of an acid of a volatile na-re, together with ſome gelatinous or oily matter, and ſmall portion of lime. The acid itſelf may probably : a compound ſalt with exceſs of acid, ſimilar to the ɔmbinations of mineral alkali and phoſphoric acid, :getable alkali and tartareous acid, and ſome others hich were conſidered as ſimple acids, until chemiſts ıd deviſed means of ſeparating their component parts. /e ſee therefore that the analyſis of the ſtone of the adder has not yet been perfectly made.

Page 209.

Homberg's experiments on human excrement.

However important the knowledge of the compo-:nt parts of fecal matter may be, to facilitate our :quaintance with the animal ſyſtem, it may eaſily be ıagined that the purſuits of the majority of chemiſts ould be directed to departments of the ſcience, hich promiſed effects of a leſs diſguſting nature. Ve poſſeſs but one ſet of experiments made on this ıbſtance, by Homberg, at the beginning of the pre-:nt century. This philoſopher, in conſequence of lchemiſtical information, inſtituted a ſet of operations pon the fecal matter of men fed entirely upon bread f Goneſſe *, and Champagne wine. He found that,

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* A ſmall town near Paris, where the moſt excellent bread is ıade.

Homberg's experiments on the human fecal matter.

when recent, it afforded, by diſtillation to dryneſs, an aqueous, clear, inſipid liquor, of a diſagreeable odour, which contained no volatile alkali; but, by continuing to diſtil the reſidue by a graduated fire, he obtained fluid and concrete volatile alkali, a fetid oil, and a coaly reſidue; ſubſtances which this imperfect method of analyſis exhibits with every kind of animal ſubſtance.

The human fecal matter, by lixiviation in water, filtration, and ſubſequent evaporation, afforded an oily ſalt reſembling nitre, which was fuſed on ignited coals, and took fire when heated to a certain degree in cloſed veſſels. The ſame fecal matter, after it had undergone a complete putrefaction for forty days, in the gentle heat of a water-bath, afterwards afforded by diſtillation a colourleſs oil without ſmell, which was the thing ſought after; but it did not fix mercury, as he had been led to expect.

Imperfect as this examination is, it is rendered ſtill leſs generally applicable by the peculiar nature of the aliments from which the matter originated. For it cannot be doubted but that, as the excrements are the reſidue of the food taken, they will differ according to the nature of that food; as is indeed ſufficiently evinced from their more obvious qualities.

Ambergris.

It is at preſent a general opinion *, that ambergris is an excrementitious ſubſtance, voided by the phy-

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* Chiefly grounded on the enquiries and obſervations of Dr. Swediar, in the Phil. Tranſ. for 1783. Mr. Magellan however mentions an undoubtedly vegetable ambergris, gathered from the tree by M. Aublet, and examined by Rouelle. Cronſtedt's Mineralogy, p. 458.

Characters of ambergris.

ter macrocephalus, or ſpermaceti whale. Ambergris found in the ſea, near the coaſts of various tropical untries; and is either white, black, aſh-coloured, llow, or grey, with black or yellow ſpecks. A ſlight armth ſoftens it, like pitch; by a greater heat it kes fire; and its chemical products reſemble thoſe bitumens, among which it has uſually been ranked. ils diſſolve it; as does likewiſe ardent ſpirit, if its antity be twelve times that of the ambergris, and s temperature boiling. An addition of eſſential oil romotes the ſolution.

Matter of perſpiration, &c.

Various other matters are rejected from animals; ch as the matter of perſpiration, the naſal mucus, ars, &c. But as none of theſe have been examined, e ſhall avoid entering into any detail of their obvious roperties.

CHAP. IV.

CONCERNING THE BLOOD, AND THE OTHER FLUID OR SOLID MATTERS, OF WHICH ANIMALS ARE FORMED.

PARTS OF ANIMALS.

The blood:

THE fluid which firſt preſents itſelf to obſervation when the parts of living animals are divided or deſtroyed, is the blood, which circulates with conſiderable velocity through veſſels called veins and arteries, diſtributed into every part of the ſyſtem. It can ſcarcely admit of doubt but that the component parts, or immediate principles of the blood, muſt differ in the various and exceedingly diſſimilar genera and ſpecies of animals which occupy the land and waters of the globe; and that there are likewiſe differences in the ſtate or compoſition of this fluid in the ſame animal, according to its ſtate of health, as well as the ſituation of the veſſels from which it may be extracted. Theſe differences can be aſcertained only by the united efforts of the anatomiſt and the chemiſt. But as the difficulty and extent of the ſubject have hitherto prevented any conſiderable progreſs, it becomes an object of neceſſity to confine our attention to the blood of man, or of ſuch quadrupeds as afford this fluid in a ſtate not obviouſly different from that of the human ſpecies.

— differences.

Recent blood is uniformly fluid, and of a ſaline or ſlightly ferruginous taſte. Under the microſcope it appears

Characters of the blood.

:ears to be compoſed of a prodigious number of red
bules ſwimming in a tranſparent fluid. After ſtand-
; for a ſhort time, its parts ſeparate into a thick red
itter, or craſſamentum, and a fluid called ſerum. If
oe agitated till cold, it continues fluid; but a con-
ent polypous matter adheres to the ſtirrer, which
repeated ablutions with water becomes white, and
s a fibrous appearance: the craſſamentum becomes
iite and fibrous by the ſame treatment. If blood be
:eived from the vein in warm water, a ſimilar fila-
entous matter ſubſides, while the other parts are
ſolved. Alkalis prevent the blood from coagulat-
g; acids, on the contrary, accelerate that effect.
the latter caſe the fluid is found to contain neutral
ts, conſiſting of the acid itſelf united with mineral
cali, which conſequently muſt exiſt in the blood,
obably in a diſengaged ſtate. Ardent ſpirit coagu-
es blood. On the water-bath, blood affords an
ueous fluid, neither acid nor alkaline; but of a faint
iell, and eaſily becoming putrid. A ſtronger heat
adually dries it, and at the ſame time reduces it to a
aſs of about one eighth of its original weight. In
is ſtate it ſlightly attracts the humidity of the air,
id effervеſces with acids; but by a longer expoſure,
r ſome months, it becomes covered with an eﬄoreſ-
nce of mild mineral alkali. By deſtructive diſtillation
is animal fluid affords a watery liquor, holding in
lution a neutral ſalt, with exceſs of volatile alkali,
it whoſe acid part has not been well aſcertained:
xt follows a light oil, a denſe coloured oil, and foul
oleaginous volatile alkali. The reſidue is a coal of
ry difficult incineration, containing common ſalt,
mineral

Habitudes with acids, &c.

Diſtillation.

mineral alkali, and an earth, which is probably a combination of lime and phoſphoric acid.

Serum of blood: The ſerum of blood exhibits marks of a diſengaged alkaline ſalt, and is greatly diſpoſed to putrefy. It unites with water in all proportions, and forms a milky fluid, which may be coagulated by acids or ardent ſpirit. An increaſe of temperature cauſes ſerum to become conſiſtent, with little or no loſs of weight, in the ſame manner as the white of egg; and it is accordingly uſed for the ſame purpoſe in clarifying liquids. From a variety of experiments, it appears highly probable that white of egg, ſerum of blood, and the pure curd of milk, do not eſſentially differ from each other: and to theſe we may perhaps add the vegetable gluten, which conſiderably reſembles cheeſe.

— reſembles white of egg, curd, and vegetable gluten:

— with alkalis and acids: Alkalis render the ſerum of blood more fluid; acids coagulate it, and exhibit the neutral ſalt they would have produced by direct combination with mineral alkali. The coagulum affords, by diſtillation, phlegm, mild volatile alkali, and a thick fetid oil; and the reſidue affords mild mineral alkali. Theſe products are the ſame as are afforded by the ſerum itſelf.

— with ardent ſpirit: Serum is alſo coagulated by ardent ſpirit, merely by the loſs of part of its water. When rendered concrete

— nitrous acid. by heat, and expoſed to the action of nitrous acid, it affords phlogiſticated air by a ſlight heat, which is followed by nitrous air; and the reſidue affords acid of ſugar, together with a ſmall portion of acid of apples.

Craſſamentum. The craſſamentum of blood, when treated in the way of diſtillation, becomes dry and brittle, at the ſame time that it emits an alkaline phlegm; this is followed by an empyreumatic ſtinking oil, and concrete volatile alkali.

Fig. 9.

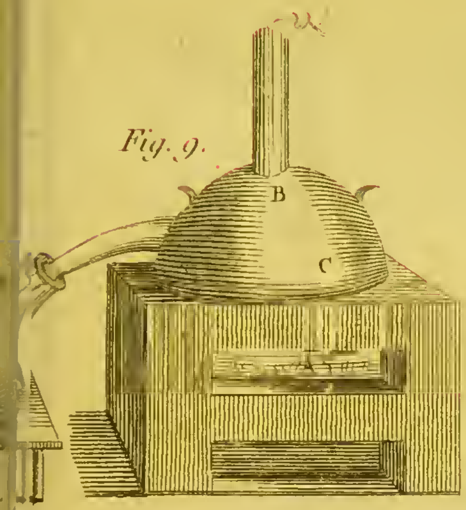
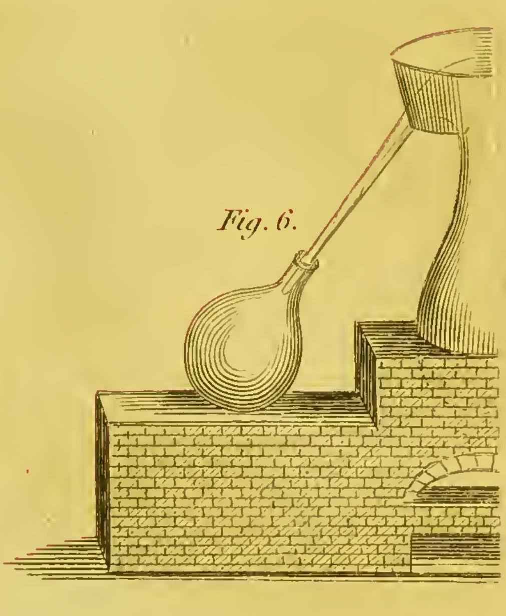


Fig. 6.



33.

Fig. 13.

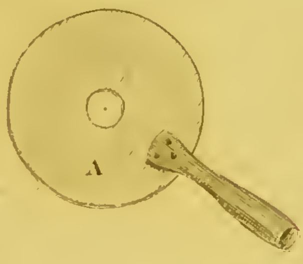


Fig. 18.

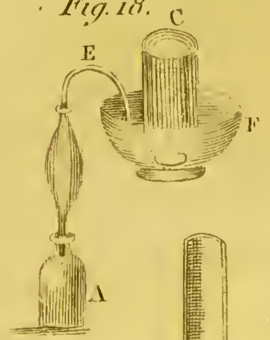


Fig. 17.

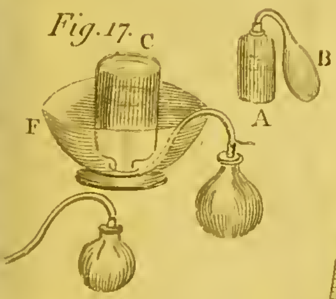


Fig. 12.

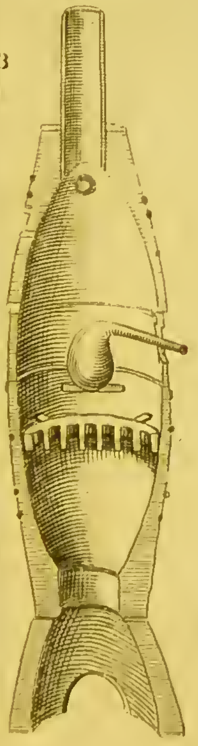
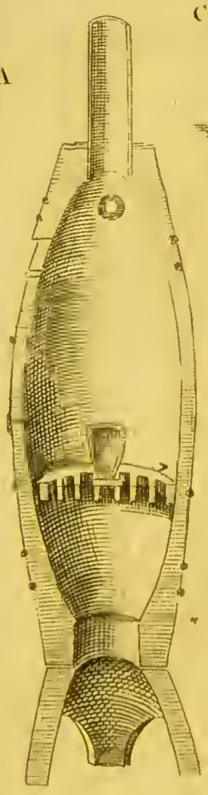


Fig. 11.



PARTS OF ANIMALS.

li. A ſpungy brilliant coal remains, which by
tment with vitriolic acid is found to contain mi-
al alkali and iron, as appears by the production of
uber's ſalt and martial vitriol: coaly matter and
ſphorated lime are then left behind.

Fibrous part of blood:

The fibrous matter, which is obtained by waſhing
red part of the blood, reſembles the ſerum in many
ts properties; though it differs from it in not being
ble in water, in becoming hard by a very gentle
t, and in not combining with alkalis. Acids unite
h it, and in particular the nitrous acid diſſolves it,
l extricates phlogiſticated and nitrous air; while
reſidue, by evaporation, affords acid of ſugar in
ſtals, a peculiar oil in flocks, and the phoſphoric ſalt
lime. Its volatile products by deſtructive diſtilla-
n are nearly the ſame as thoſe of ſerum: but its
due contains no ſalt, except the combination of
e and phoſphoric acid; the other ſalts it might
re contained having probably been carried off dur-
the waſhing. Marine acid forms a green jelly
h the fibrous parts of the blood.

— with acids.

Deſtructive diſtillation.

Soft parts of animals.

The ſoft and flexible parts of animals appear to be
npoſed of principles greatly reſembling thoſe of the
od. When they are boiled in water, the fluid ex-
cts that peculiar animal ſubſtance which is known
the name of jelly or glue. This is afforded by the
ite parts moſt plentifully, though it is found in
noſt every part of the animal ſolids. Its appear-
ce and inſipidity, together with its other obvious
perties, are well known. It is ſoluble in water, in
proportions; is more fluid when hot than when

Jelly or glue.

Jelly or glue.

cold. Alkalis and acids both diſſolve it. By ſpontaneous decompoſition it firſt becomes acid, and ſoon afterwards putrefies. By deſtructive diſtillation it affords an alkaline phlegm, an empyreumatic oil, and a ſmall quantity of volatile alkali. The reſidual coal is voluminous, not eaſily incinerated, and contains common ſalt, with the phoſphoric ſalt of lime. The habitude of the nitrous acid with glue, or jelly, is the ſame as with other animal ſubſtances; phlogiſticated air and nitrous air are diſengaged, and the reſidue affords acid of ſugar.

Analyſis of the fleſh of animals.

Beſides the parenchymatous and cellular ſubſtance of which the muſcles of animals are formed, their veſſels contain fluids poſſeſſed of various properties. Theſe may be obtained by preſſure, and the judicious application of water and ardent ſpirit, either with or without heat. If fleſh be waſhed in cold water, a portion of blood and gelatinous matter, together with ſaline matter, are extracted: the reſidue being digeſted in ardent ſpirit, is by that means deprived of an extractive or ſaponaceous ſubſtance; and ſubſequent ebullition in water diſſolves the gelatinous part, at the ſame time that it deprives it of ſuch portions of extract and ſalt as had been defended from the action of the two former ſolvents. The fat is alſo liquefied by this operation, and ariſes to the ſurface. By ſlow evaporation of the aqueous ſolution, made in the cold, the albuminous part, or ſerum, coagulates, and may be ſeparated on the filter: the filtered liquor will afford its ſalt by evaporation: the ſpirituous ſolution depoſits the extractive matter by evaporation: and the decoction affords the jelly, with the fat oil, which ſwims

Analyſis of the fleſh of animals.

at the ſurface and congeals by cooling. The remaining ſolid ſubſtance conſiſts merely of the fibrous matter, which is white, inſipid, and inſoluble in water. This affords much volatile alkali, and a very fetid oil, by diſtillation; and it gives out a large quantity of phlogiſticated air when treated with nitrous acid. In a word, it has all the characters of the fibrous part of the blood, and is probably formed by the depoſition of that ſubſtance *.

The extractive or ſaponaceous matter obtained by the evaporation of the ſpirit, is ſoluble likewiſe in water; it ſwells up and liquefies by heat, and emits a ſmell ſomewhat reſembling that of burned ſugar: it is this ſubſtance which predominates in the brown cruſt that covers the ſurface of roaſted meat. The ſalt afforded by the decoction of fleſh has not been perfectly examined; but it ſeems to conſiſt of the phoſphoric acid, united partly with the vegetable alkali, and partly with lime.

Fat of animals.

The fat of animals is a ſubſtance of the ſame nature as thoſe oils, which are called fat oils in the vegetable kingdom. Its conſiſtence is various in different animals, and in different parts of the ſame animal. The fat of the human ſpecies and of quadrupeds is conſiſtent, and of a white or yellowiſh colour; the fat of the internal parts being uſually firmer than that which is placed among the muſcles. It poſſeſſes all the characters of vegetable fat oils; though the crude fat of animals appears to contain a conſiderable quantity of

Page 421.

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* Fourcroy, iv. 427.

PARTS OF ANIMALS.

mucilage or jelly peculiar to that kingdom, which may for the moſt part be waſhed off by agitation in a large quantity of hot water.

Acid of fat.

The acid of fat is conſidered as belonging to the animal kingdom, though indeed it is no leſs abundant in the fat oils of vegetables. It may be obtained by diſtillation. Or otherwiſe a quantity of ſuet may be melted, and mixed with quick-lime: as ſoon as the mixture is cold, it muſt be boiled in a large quantity of water. After filtration and evaporation, the calcareous ſalt formed by the combination of that earth with the acid of the fat, is obtained of a brown colour. A ſlight calcination in a crucible renders it purer, by the deſtruction of a portion of inflammable matter; and by ſolution, filtration, and the addition of a certain quantity of fixed air to precipitate the ſuperfluous lime, a clear ſolution of the acid of fat, neutralized with calcareous earth, is obtained. Evaporation of this fluid affords the pure white ſalt; and this, when diſtilled with the addition of vitriolic acid, affords the acid of fat, which comes over into the receiver, while the lime and vitriolic acid remain in the retort, in the form of ſelenite.

Characters of the acid of fat.

The general characters of the acid of fat are the following:—It is liquid, fuming, and of a penetrating ſmell; decompoſable by fire, which turns it yellow, and extricates or produces fixed air. Blue colours are ſtrongly reddened by it. Water diſſolves it in all proportions. With lime, and alſo with the fixed alkalis, it forms cryſtallizable ſalts, which are not decompoſed by heat. Siliceous earth appears to be

ſoluble

uble in, or corroded by, this acid; and it acts on
eral of the metals.

Method of obtaining ſpermaceti.

Spermaceti is a peculiar ſubſtance, of the nature of
oil, which is found in the head of a ſpecies of
ale. One of theſe fiſhes affords ſome tons of brains,
ich are firſt groſsly freed from the oil, by draining
d preſſing; and afterwards more perfectly purified,
ſteeping them in a lye of alkaline ſalt and quick-
ne, which converts the remains of the oily matter
o ſoap. The brains being then waſhed with water,
pear of a ſilver whiteneſs; and nothing more is then
quired to complete the preparation, than to cut
em in pieces with wooden knives, and ſpread them
road to dry. Good ſpermaceti is in fine white
kes, gloſſy, and ſemi-tranſparent; rather unctuous
the touch, though dry, and in ſome meaſure friable.
ſmell is faintiſh, though not diſagreeable; and it
s ſcarcely any taſte, on account of its being either
arly or totally inſoluble in the ſaliva: expoſure to
e air renders it yellowiſh and rancid in proceſs of
ne; and that the more readily, in proportion as
e original purification has been leſs complete. It
ay however be rendered white and ſweet again, by
eping it afreſh in cauſtic alkali, and waſhing it in
ter.

Its characters:

—and habitudes.

It is ſcarcely, if at all, more combuſtible than
llow; and is a much better material for candles,
cauſe leſs fuſible and greaſy By diſtillation it
tally riſes, leaving no coal behind; but its com-
nent parts do not riſe together. Four ounces of
is ſubſtance afforded three ounces and a half of a

clear yellowiſh butyraceous oil, reſembling oil of wax in ſmell, and coagulate in the cold, like that ſubſtance; a drachm and a half of the product conſiſted of phlegm, and the reſt was waſted or diſſipated in the proceſs *.

Habitudes of ſpermaceti with various ſubſtances.

'Water has no other effect upon ſpermaceti, when boiled with it, than to ſeparate a ſmall quantity of mucilaginous, or perhaps ſaponaceous matter, which is probably an impurity. Oils diſſolve it, by the aſſiſtance of heat; hot ardent ſpirit likewiſe diſſolves it, but lets the greateſt part fall upon cooling; ether diſſolves it very readily; ſulphur combines with this ſubſtance, in the ſame manner as it does with fat oils; the nitrous and marine acids have no action on it; concentrated vitriolic acid diſſolves it, but lets it fall again by heat.

Conjecture reſpecting its ſingular properties. Page 421—423. 499.

'It has been conjectured that this ſingular ſubſtance bears the ſame relation to fat oils as camphor does to the eſſential oils. Wax appears to have the ſame relation to fixed oils, as reſin has to the eſſential; that is to ſay, both have been rendered concrete by the abſorption of vital air. But ſpermaceti and camphor ſeem to differ in ſome other leading particular; probably in the abſence of acid, or of any baſis which can eaſily be acidified by the action of nitrous or other acids. Much information would no doubt be derived from a careful examination of the products which theſe ſeveral ſubſtances afford by combuſtion.

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* Neumann's Chemiſtry, by Lewis, ii. 422. Fourcroy, iv. 447, ſays that ſpermaceti forms a ſoap with cauſtic alkali; which is contrary to the poſitive aſſertion of Neumann, from whom the foregoing part of the text is taken.

The

PARTS OF ANIMALS.

Bones.

The bones of men and quadrupeds owe their great mneſs and ſolidity to a conſiderable portion of the oſphoric ſalt of lime which they contain. When eſe are raſped ſmall, and boiled in water, they afford latinous matter, and a portion of fat or oil, which cupied their interſtices. By deſtructive diſtillation ey afford alkaline phlegm, a fetid oil, and much latile alkali; leaving a coal not eaſily burned. In open fire, bones are inflamed by virtue of their oil, d emit an offenſive empyreumatic ſmell. The hite, friable, and incombuſtible reſidue, conſiſts iefly of lime and phoſphoric acid in combination. affords a ſmall quantity of mild mineral alkali by aſhing with water. This white matter is decom-oſable by fuſion, with mild fixed alkalis, which nite with the phoſphoric acid, at the ſame time that he fixed air converts the lime into chalk. Acids kewiſe diſengage the phoſphoric acid, by uniting ith the lime. The nitrous or the vitriolic acids are oſt commonly uſed in this proceſs.

White reſidue.

Page 202.

CHAP. V.

CONCERNING THE BILE, THE GASTRIC JUICE, AND THE ACID OBTAINED FROM ANTS.

ANIMAL FLUIDS.

THE fluids which remain to be conſidered, as compoſing part of animals, are the bile, the gaſtric juice, and ſuch acids as are obtained by treatment of animal matters.

Characters of the bile or gall.

The bile or gall is a fluid of a yellowiſh green colour, exceſſively bitter, and of a faint nauſeous ſmell. It is ſeparated from the blood in a glandular viſcus, well known by the denomination of the liver, and in moſt animals is collected in a veſſel called the gall bladder. The gall of oxen is that which chemiſts have more particularly examined. Its conſiſtence is almoſt gelatinous; by agitation it forms a froth ſimilar to that of a ſolution of ſoap. Water diſſolves it in all proportions; and this ſolution produces the ſame effect as a ſolution of ſoap in ſcouring cloths. All the acids decompoſe it, and produce a coagulum, which ſeparates from the watery ſolution, at the ſame time that the acid becomes neutralized by a portion of mineral alkali which unites with it. The coagulum, which may be ſeparated by the filter, is thick, viſcid, very bitter, and very inflammable. It appears ſo far of a reſinous nature, as to be totally ſoluble in ardent ſpirit: hence it follows that the bile conſiſts principally of a ſoap compoſed of this matter, and the mineral alkali. It alſo contains a quantity of ſerum, which cauſes it to coagulate by heat, or by the action of ardent ſpirit, and diſpoſes it to putrefy. Ardent ſpirit takes up the ſaponaceous matter, and leaves the ſerum behind.

Deſtructive diſtillation of the bile.

Deſtructive diſtillation ſeparates firſt an aqueous fluid, neither acid nor alkaline, but diſpoſed to putrefy. Nothing elſe paſſes over upon the water-bath. The reſidue is of a dark colour, very tenacious, like pitch, and totally ſoluble in water. If the diſtillation be continued with caution, on account of the ſwelling of the matter, the products are a yellowiſh alkaline phlegm, empyreumatic oil, much volatile alkali, and the elaſtic products conſiſt of fixed and inflammable air. A conſiderable coal remains, which contains mineral alkali, an earth, which is probably a combination of phoſphoric acid and lime, and a ſmall portion of iron.

Biliary concretions.

The nature of the biliary concretions which are formed in the gall bladder, has not yet been completely aſcertained. Theſe are found ſometimes of an irregular texture, and a brown, black, yellowiſh, or greeniſh colour; others conſiſt of tranſparent cryſtalline laminæ, ſometimes radiated from the centre to the circumference. * Two ounces of biliary calculus, of a grey colour without, and browniſh green within, were diſſolved in twelve times their weight of pure ardent ſpirit, by the aſſiſtance of a moderate heat. The hot ſolution being filtered, ſoon depoſited, by cooling, a large quantity of laminated white brilliant cryſtals, reſembling the concrete acid of borax. The

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* Fourcroy, in the Annales de Chimie, iii. 245.

Examination of the biliary calculus.

quantity amounted to near one ſixteenth of the whole calculus; and, upon examination, it poſſeſſed the following properties:—It was inflammable, and melted by a gentle heat in a ſpoon, with a ſmell like wax, and cooled into a brittle ſubſtance of a cryſtallized fracture: a ſudden heat volatilized the whole. Water had no action upon it when cold; but boiling water cauſed it to melt, and float on the ſurface like an oil, which became concrete by cooling. Cauſtic alkalis converted it into ſoap. Nitrous acid diſſolved it quietly, and the addition of water ſeparated it unaltered. Ardent ſpirit diſſolved it by heat; but the greateſt part was ſeparated by cooling. Theſe characters indicate that it is a ſubſtance of the ſame nature as ſpermaceti. The author * of this valuable diſcovery has alſo found that the cryſtallized gall ſtones contain this matter ſtill more abundantly; and that it exiſted in conſiderable quantity in an human liver which had been expoſed to the air for ſeveral years, and had loſt its volatile parts by putrefaction. The aſſiduous reſearches of the ſame philoſopher into the animal œconomy, have detected the ſame ſubſtance, in a ſaponaceous form, in bodies which had been many years buried under ground.

The gaſtric fluid.

A conſiderable number of chemiſts have examined the properties of the fluid which appears to be the menſtruum of digeſtion in the ſtomachs of animals. It is certain that in this proceſs the aliments become converted into a ſoft or pulpy maſs, moſt probably by the action of a ſolvent, aſſiſted by their own tendency

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* Fourcroy, in the Annales before cited, iii. 120.

to

The gaſtric fluid.

pontaneous decompoſition, at the temperature of body of the animal. The gaſtric juice procured n the ſtomachs of animals which have been kept ing for a conſiderable time, appears to differ ac- ding to their reſpective natures. It is thought to ſeſs a ſolvent power upon animal and vegetable ſtances, without any preference of affinity; but s laſt circumſtance is ſcarcely probable. A power- antiſeptic quality is reckoned among its attributes; t there are ſome reaſons to think that in graminivo- us animals it has the contrary effect. In theſe laſt, re eſpecially, it contains a diſengaged acid, which ems to be the phoſphoric. And upon the whole, it pears that accurate and deciſive experiments are ſtill nting, to determine the nature of this compounded d variable fluid, which is of ſuch important uſe in e animal œconomy.

Acid of ants.

Of the acids which are conſidered as belonging ore eſpecially to the animal kingdom, we have ready attended to thoſe afforded by milk, by fat, the ſtone of the bladder, by ſilk worms, and by e calcination of blood with an alkali, in the prepa- tion of Pruſſian blue; it therefore remains only for s to give an account of the acid which is afforded by nts. Theſe animals appear to contain a peculiar cid, in a veſſel placed near the hinder part of their odies*, which they eject when enraged; or moiſten heir fangs with it, to render their bite more painful. The acid may be obtained by diſtillation of the ants

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* Wiegleb's Chemiſtry, by Hopſon, p. 191. On this acid, onſult the authors there referred to; and alſo Fontana, in the Journal de Phyſique for 1778, part ii.

with

Acid of ants.

with water, and ſubſequent preſſure of the reſidue: or the ants may be tied up in a bag, and twice infuſed in hot water; from which infuſion as much acid may be diſtilled off as can be had without burning the reſidue. It may be purified by ſaturating it with alkali, filtrating, and evaporating part of the liquor, and diſtilling it with half its weight of vitriolic acid: or, more conveniently, the rectified acid may be expoſed to the action of a freezing atmoſphere, which congeals its aqueous part. This acid has a conſiderable reſemblance to vinegar when it is diluted. It acts upon, and combines with, alkalis, ſoluble earths, and metals, and forms peculiar compounds; from which, as well as the order of its elective attractions, its title to be conſidered as a diſtinct or peculiar acid is eſtabliſhed.

Deſtructive diſtillation converts it, like the vegetable acids, into fixed air and inflammable air.

A P P E N D I X.

ARIOUS TABLES USEFUL TO CHEMISTS.

AN ACCOUNT OF THE TABLES.

TABLE I. contains a ſeries of numbers, expreſſing the comparative heats of bodies. It is co- ed from Crawford's Experiments and Obſervations Animal Heat, and the Inflammation of Combuſtible odies: London, 1788. The principles on which this able is formed, have been explained in page 14 of r Work, and elſewhere. Nothing more need there- re be ſaid, than that the numbers are here reduced one common ſtandard of compariſon, water being aſſumed

ACCOUNT OF TABLES.

Table of comparative heats.

aſſumed as unity. As theſe numbers are deduced from the thermometrical changes undergone by the ſeveral bodies in like ſituations, it is clear that they are of uſe to indicate thoſe changes, for they will be inverſely as the numbers themſelves.

Table of weights.

TABLE II. contains the weights of different countries, compared in French and Engliſh grains. The value of this Table is obvious, and its character may be ſeen at page 70.

Table of ſpecific gravities.

TABLE III. exhibits the ſpecific gravities of bodies. In compiling this, I had Briſſon's Table at the end of Lavoiſier's Traité Elementaire de Chimie, and Muſchenbroek's large Table in his Cours de Phyſique, before me. Some few ſpecific gravities are from other authors, or from experiment. It appeared uſeleſs to carry it to more than four places of figures, as the temperatures were not noted, and the various ſpecimens of the ſame ſubſtance often differ in the third figure. Theſe aſſertions may be thought to require proof: for which reaſon I ſhall obſerve, that by experiment I find that the fifth figure changes at every three degrees of Fahrenheit's thermometer; that lead, tin, and probably all other metals caſt out of the ſame fuſion, vary in their ſpecific gravities in the third figure, from circumſtances not yet determined, but moſt likely from the cooling, as is ſeen in the hardening of ſteel; that ſalts, and other artificial preparations, retain more or leſs of the ſolvent they were ſeparated from, according to the temperature at which it was effected; and that all parts of organized ſubſtances not only differ according to the place of their production, their age, and other circumſtances, but like-

likewiſe from their dryneſs, moiſture, and manner of preſervation.

ACCOUNT OF TABLES.

Table of ſpecific gravities of aerial fluids.

TABLE IV. is taken from the ſeventh Table of M. Lavoiſier's Traité Elementaire. I have in another place * mentioned the ſtrong objections which may be urged againſt the ſuppoſed or implied accuracy of theſe weights, taken to ſo many places of figures. In that place, as the object of attention was of a controverſial nature, it was proper to ſpeak far within compaſs; but on the preſent occaſion I muſt obſerve, that the moſt accurate practical chemiſts would conſider a true determination of the ſpecific gravities of aerial fluids to three, or even two places of figures, as a great and valuable acquiſition; and though I regard this Table as the beſt we poſſeſs, yet in every inſtance I doubt the accuracy of the third decimal, and in moſt of them the ſecond. The column of Engliſh grains is ſubſtituted inſtead of the weight of a cubic foot French, which occupies that place in the original.

Table of expanſions of airs.

TABLE V. is taken from an excellent Paper of Morveau, in the firſt volume of the Annales de Chimie. The experiments were made by M. Prieur du Vernois upon the quantity of about 15½ cubic inches French, under the preſſure of about 27 French inches of mercury, which anſwer to near 28 Engliſh. The manner in which this inveſtigation was conducted, does great credit to both the philoſophers who were concerned in it; and the Eſſay itſelf, of which this Table is the reſult, is highly deſerving of the attention of thoſe

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* Preface to the ſecond edition of Kirwan's Eſſay on Phlogiſton, p. x.

ſtudents who wiſh to know the precautions required in theſe delicate experiments, as well as of the ſtrict enquirer who may be deſirous of knowing how far he may depend on the Table itſelf.

Tables of elective attractions.

TABLES VI. to XI. contain in ſubſtance the two Tables of Attractiones Electivæ Simplices which are placed at the end of Bergman's Treatiſe on Elective Attractions, inſerted in the third volume of his Opuſcula, and of which we have had a ſeparate tranſlation into Engliſh. They have been ſince copied into a variety of works, and in moſt with amendments. I have not however ventured to make any alteration, except ſuch as tended to facilitate the inſertion of them in the regular pages of the book, inſtead of adopting the much leſs convenient mode of printing on a large ſheet to be folded out. Hence it is the arrangement of the columns only which is altered, and repetitions avoided; except that in Table VIII. there is a notice that the perlate acid, vital air, the matter of heat, and ſiderite, are left out; the reaſons for which need not be repeated here. Two inducements rendered it moſt eligible to retain the Tables, in other reſpects, the ſame as Bergman left them. The one was, that they might continue to be Bergman's Tables; and the other was, that, if I had been prepared for the arduous taſk of compoſing new Tables, it would have been incumbent on me to have fully ſtated my reaſons for the arrangements I might have adopted; which would have been incompatible with the limits of an Elementary Treatiſe.

With regard to theſe Tables, after earneſtly recommending the ſtudent to peruſe the work from

ACCOUNT OF TABLES.

Elective attractions.

hich they are extracted, it may be obſerved, that e ſubſtances at the heads of the columns are condered as ſimple, with regard to the facts enumerated theſe ſketches, and ſo likewiſe are the ſubſtances inrted in the columns. The order of poſition denotes at the higher any ſubſtance ſtands in any column, e ſtronger is its elective attraction to the ſubſtance the head of that column. The under part of each able exhibits the attractions in the dry way, and uſt be conſidered as entirely diſtinct from the upper art. The horizontal lines between the ſubſtances in e columns denote that their poſitions, or comparative owers of attraction, are well determined; and, whenver theſe lines are wanting, the poſitions are more or ſs conjectural. Hence it may be ſeen how much mained to be done at the time the great Bergman nſtructed theſe Tables.

TABLE XII. exhibits an approximation towards xpreſſing the powers of elective attraction between odies generally applied. It is evident that the ables of ſimple elective attraction expreſs only e order in which the ſeveral enumerated ſubſtances rpaſs each other in power to adhere to the common bſtance at the head of each column; and do not y any means ſhew what will happen when a compound of two principles is applied to another comound alſo containing two principles, as in the caſes lled double elective attraction. We cannot, in ct, decide in circumſtances of this nature, unleſs we e previouſly acquainted with the ſum of the two tractions which tend to preſerve the original cominations, and are on that account very expreſſively

ACCOUNT OF TABLES.

denominated by Mr. Kirwan quieſcent attractions; and alſo with the ſum of the other two attractions which tend to form new combinations, and are by the ſame chemiſt called the divellent attractions. Thus, for example, if vitriolated tartar, or the compound of vegetable alkali and vitriolic acid, be preſented to the marine ſalt of lime, we cannot foretel the conſequence from any ſimple Tables, becauſe theſe will not ſhew whether the ſum of the powers which tend to preſerve the union of the alkali and vitriolic acid, and alſo of the lime and marine acid, be in fact greater or leſs than thoſe by which the alkali tends to combine with the marine, and the lime with the vitriolic acid, and form the new compound of ſalt of ſylvius and ſelenite. Hence we ſee the great advantage which the ſcience of chemiſtry would derive from an extenſive numerical Table founded on experiments of the nature of that now before us. For, in the preſent inſtance, we find from the Table, that the vegetable alkali and vitriolic acid adhere with a power expreſſed by the number 62; while the lime and marine acid adhere with a power denoted by 20. Theſe are the quieſcent affinities, and their ſum is 82. On the other hand, by the ſame Table, we find that the attraction between vitriolic acid and lime is 54; and between vegetable alkali and marine acid 32. Theſe are the divellent affinities, and their ſum is 86. The latter muſt therefore prevail; that is, the combinations will be changed by the vitriolic acid melting with the lime, and forming ſelenite; while the marine acid combines with the vegetable alkali, and forms ſalt of ſylvius.

ACCOUNT OF TABLES.

Table of ingredients in earths and ſtones.

TABLE XIII. ſhews the proportion of ingredients in earths and ſtones. It is taken from Kirwan's Mineralogy. The extenſive and indefatigable reſearches of this author into all the ſources of chemical information, and the numerous additions he has himſelf made to the ſcience, have enabled him to render this Table more perfect than any which is elſewhere to be met with. Much however remains ſtill to be done, in every part of it, before we can depend on its accuracy throughout; and we hope the author will add the labour of perfecting it, to the other advantages which the ſcientific world has derived from his exertions.

TABLE I. The Comparative Heats of different Bodies.

Inflammable air	21.4000
Dephlogiſticated air	4.7490
Atmoſpherical air	1.7900
Aqueous vapour	1.5500
Fixed air	1.0454
Arterial blood	1.0300
Water	1.0000
Freſh milk of a cow	.9999
Venous blood	.8928
Phlogiſticated air	.7936
Hide of an ox, with the hair	.7870
Lungs of a ſheep	.7690
Lean of the beef of an ox	.7400
Alcohol	.6021
Rice	.5060
Horſe beans	.5020
Spermaceti oil	.5000
Duſt of the pine tree	.5000
Peas	.4920
Wheat	.4770
Barley	.4210
Oats	.4160
Vitriolic acid	.4290
Pitcoal	.2777
Charcoal	.2631
Chalk	.2564
Ruſt of Iron	.2500
Waſhed diaphoretic antimony	.2272
Calx of copper, nearly freed from air	.2272
Quicklime	.2229
Cinders	.1923
Aſhes of cinders	.1855
Ruſt of iron, nearly freed from air	.1666
Waſhed diaphoretic antimony, nearly freed from air	.1666
Aſhes of the elm-tree	.1402
Calx of zinc, nearly freed from air	.1369
Iron	.1269
Braſs	.1123
Copper	.1111
White calx of tin, nearly freed from air	.0990
Regulus of zinc	.0943
Aſhes of charcoal	.0909
Tin	.0704
Yellow calx of lead, nearly freed from air	.0680
Regulus of antimony	.0645
Lead	.0352

TABLE II. The Weights of different Countries.

Place and Denomination of Weight.	Marc	oz.	gros.	grains.	F. grains.	E. grains.
Berlin. The marc of 16 loths		7	5	16	4408	3616.3
Berne. Goldſmiths weight of 8 ounces	1	—	½	4	4648	3813.2
Berne. Pound of 16 ounces, for merchandiſe	2	1	½	6	9834	8067.7
The common pound varies very conſiderably in other towns of the Canton.						
Berne. Apothecaries weight of 8 ounces	—	7	5½	26	4454	3654.
Bonn.	—	7	5	6¾	4398¾	3608.6
Bruſſels. The marc, or original troyes weight	1	—	—	21	4629	3797.6
Cologn. The marc of 16 loths	—	7	5	11	4403	3612.2
Conſtantinople. The cheki, or 100 drachms	1	2	3	28	6004	4925.6
Copenhagen. Goldſmiths weight, commonly ſuppoſed equal to the marc of Cologn	—	7	5½	10⅓	4438⅓	3641.2
Copenhagen. Merchants weight of 16 loths	1	—	1	22½	4702½	3857.9
Dantzick. Weight commonly ſuppoſed equal to the marc of Cologn	—	7	5	3½	4395½	3606.
Florence. The pound (anciently uſed by the Romans)	1	3	½	20	6392	5244.
Genoa. The peſo ſottile	1	2	2½	30	5970	4897.7
Genoa. The peſo groſſo	1	2	3	5	5981	4906.7
Hamburgh. Weight; commonly ſuppoſed equal to the Cologn marc	—	7	5	7¾	4399¾	3609.4
Hamburgh. Another weight	—	7	7	23	4559	3740.2
Liege. The Bruſſels marc uſed; but the wt. proved	1	—	—	24	4632	3800.1
Liſbon. The marc, or half pound	—	7	3½	34	4318	3542.4
London. The pound troy	1	4	1½	1	7021	5760.
London. The pound avoirdupoiſe	1	6	6½	6	8538	7004.5
Lucca. The pound	1	3	—	23¼	6359¼	5217.
Madrid. The marc royal of Caſtile	—	7	4	8	4328	3550.7
Malta. The pound	1	2	2½	21	5961	4890.4
Manheim. (The Cologn marc)	—	7	5	10¼	4402¼	3611.5
Milan. The marc	—	7	5	33	4425	3630.2
Milan. The libra groſſa	3	—	7½	—	14364	11784.
Munich. (The Cologn marc)	—	7	5	11½	4403½	3612.3
Naples. The pound of 12 ounces	1	2	3½	27	6039	4954.3
Ratiſbon. The weight for gold; of 128 crowns	1	6	—	24	8088	6635.3
Ratiſbon. The weight for ducats; of 64 ducats	—	7	2	32	4208	3452.3
Ratiſbon. The marc of 8 ounces	1	—	—	24	4632	3800.1
Ratiſbon. The pound of 16 ounces	2	2	4½	6	10698	8776.5
Rome. The pound of 12 ounces	1	3	½	14	6386	5239.
Stockholm. The pound of 2 marcs	1	5	7	8	8000	6563.1
Stuttgard. (The Cologn marc)	—	7	5	11¾	4403¾	3612.6
Turin. The marc of 8 ounces	1	—	—	22¼	4630¼	3799.
At Turin they have alſo a pound of 12 of the above ounces. But, in their apothecaries pound of 12 ounces, the ounce is one ſixth lighter.						
Warſaw. The pound	1	5	2	12	7644	6271.
Venice. The libra groſſa of 12 ounces	1	7	4½	25½	8989½	7374.5
Venice. The peſo ſottile of 12 ounces	1	1	6½	24	5676	4656.5
In the towns dependant on Venice, the pound differs conſiderably in each.						
Vienna. The marc of commerce	1	1	1	16	5272	4325.
Vienna. The marc of money	1	1	1	26	5282	4333.3
France. The grain	—	—	—	—	1.	1.21895
England. The grain	—	—	—	—	0.82039	1.

TABLE III. The Specific Gravities of Bodies.

Pure gold caſt	19258
— hammered	19362
Standard gold caſt	17486
— hammered	17589
Pure ſilver caſt	10474
— hammered	10511
Standard ſilver in coin	10391
Crude platina in grains	15602
Platina purified and fuſed	19500
— hammered	20337
— drawn into wire	21042
— laminated	22069
Mercury	13568
Lead fuſed	11352
Copper fuſed	7788
— drawn into wire	8878
Braſs caſt	8396
— in wire	8544
Iron caſt	7207
— bar	7788
Steel, ſoft and not hammered	7840
— hardened	7816
Tin, Engliſh, fuſed	7291
— hammered	7299
Malacca tin fuſed	7296
— hammered	7306
Biſmuth	9823
Nickel	8660
Arſenic, the regulus	5763
Cobalt	7812
Zinc	7191
Antimony	6702
Manganeſe	6850
Wolfram	17600
Diamond	3521
Ruby	4283
— ſpinell	3760
Topaz, oriental	4011
— Brazilian	3536
— Saxon	3564
Sapphire, oriental	3994
Emerald	2775
Adamantine ſpar	4180
Jargon of Ceylon	4615
Rock cryſtal from Madagaſcar	2653
Quartz	2654
Agate	2590
Onyx	2637
Muſcovy talc	2792
Common ſlate	2672
Calcareous ſpar	2715
Alabaſter	2730
White marble	2716
Lime ſtones from	1386
— to	2390
Ponderous ſpar	4474
Fluor ſpar	3180
Pumice ſtone	914
Green glaſs	2620
Engliſh crown glaſs	2520
White flint glaſs, Engliſh	3290
Another piece	3216
White flint glaſs, for achromatic uſes	3437
White glaſs, French	2892
Glaſs of S. Gobin	2488
Brimſtone	1990
Phoſphorus	1714
Yellow amber	1078
Diſtilled water	1000
Sea water	1026
Common ſpirit of wine	837
Spirit of wine, the pureſt which can be had by mere diſtillation	820
Vitriolic ether	739
Nitrous	909
Marine	730
Acetous	866
Concentrated vitriolic acid	2125
— nitrous acid	1580
— marine acid	1194
Fluor acid	1500
Oil of olives	915
— of ſweet almonds	917
Linſeed oil	940
Naptha	708
Gum claſtic	933
Camphor	989
Yellow wax	965
White Do.	969
Spermaceti	943
Tallow	942
Heart of oak	1170
Cork	240
Egg new laid	1081

TABLE IV. The Specific Gravities of Aerial Subſtances; the Barometer ſtanding at 30 Inches, and the Thermometer at + 55°.*

Names of Aerial Subſtances.	Weight of one cubic Inch. French.	Engliſh.	From the Experiments of
	French grains.	Engliſh grains.	
Atmoſpheric air	0.46005	0.45689	M. Lavoiſier.
Phlogiſticated air	0.44444	0.44139	The ſame.
Vital air	0.50694	0.50346	The ſame.
Inflammable air	0.03539	0.03515	The ſame.
Fixed air	0.68985	0.68511	The ſame.
Nitrous air	0.54690	0.54314	M. Kirwan.
Alkaline air	0.27488	0.27299	The ſame.
Vitriolic air	1.03820	1.03109	The ſame.

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* Strictly the numbers are 29.84 inches and 54.5 degrees; anſwering to 28 French inches, and 10 deg. of Reaumur.

TABLE V. The Expanſions of Aerial Subſtances by Heat, from the Freezing to the Boiling Points of Water. For every Interval of 20° of Reaumur's, or 45° of Fahrenheit's Thermometer.

Names.	From 32° to 77°	From 77° to 122°	From 122° to 167°	From 167° to 212°	Total From 32° to 212°
Common air	$\frac{1}{12.87}$	$\frac{1}{5.61}$	$\frac{1}{2.49}$	[$\frac{1}{3.[illegible]}$]	$\frac{1}{1.067}$
Vital air	$\frac{1}{22.12}$	$\frac{1}{7.92}$	$\frac{1}{1.53}$	[3 + $\frac{1}{1.[illegible]3}$]	4 + $\frac{1}{2.69}$
Phlogiſt. air	$\frac{1}{29.41}$	$\frac{1}{7.41}$	$\frac{1}{1.82}$	[5 + $\frac{1}{57.2}$]	5 + $\frac{1}{1.062}$
Inflam. air	$\frac{1}{11.01}$	$\frac{1}{6.92}$	[$\frac{1}{6.85}$]	[$\frac{1}{[illegible]8.87}$]	$2.\frac{1}{5}$
Nitrous air	$\frac{1}{13.33}$	$\frac{1}{9.00}$	$\frac{1}{3.739}$	[$\frac{1}{6.85}$]	$\frac{1}{1.63}$
Fixed air	$\frac{1}{9.049}$	$\frac{1}{5.099}$	$\frac{1}{7.31}$	[$\frac{1}{3.69}$]	1 + $\frac{1}{10[illegible].3}$
Alkaline air	$\frac{1}{3.58}$	$\frac{1}{1.75}$	1 + $\frac{1}{1.35}$	[3 + $\frac{1}{1.69}$]	5 + $\frac{1}{5.278}$

⁂ The numbers between brackets are uncertain.

TABLE VI. Simple Elective Attractions.

ACIDS.

In the Humid Way.

Vitriolic Acid.	Nitrous Acid.	Marine Acid.	Fixed Air.	Acid of Borax.	Acid of Amber.	Acetous Acid distilled.
Barytes	Veg. alkali ?	Veg. alkali ?	Barytes	Lime	Barytes	Barytes
Veg. alkali	Min. alkali ?	Min. alkali ?	Lime	Barytes	Lime	Veg. alkali
Min. alkali	Barytes ?	Barytes ?	Veg. alkali	Magneſia	Magneſia	Min. alkali
Lime	Lime	Lime	Min. alkali	Veg. alkali	Veg. alkali	Vol. alkali
Magneſia	Magneſia	Magneſia	Magneſia	Min. alkali	Min. alkali	Lime
Vol. alkali	Vol. alkali	Vol. alkali	Vol. alkali	Vol. alkali	Vol. alkali	Magneſia
Clay	Clay	Clay	Clay	Clay	Clay	Clay
Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces
Water	Water	Water	Water	Water	Water	Water
Ardent ſpirit	Ardent ſpirit	Ardent ſpirit	Ardent ſpirit	Ardent ſpirit	Ardent ſpirit	Ardent ſpirit
Phlogiſton	Phlogiſton	Phlogiſton		Phlogiſton	Phlogiſton	Phlogiſton
N. B. The ſulphureous or volatile vitriolic acid follows the ſame order in the humid way.	N. B. The fuming nitrous acid follows the ſame order in the humid way.	N. B. The dephlogiſticated or aerated marine acid follows the ſame order in the humid way.		N. B. The ſame order is followed by the acids of ſugar or ſorrel; tartar; and lemon.	The order in which the metallic calces precipitate each other in acids, is the reverſe of that in the column of phlogiſton, in Table IX. Conſult page 132.	
			In the Dry Way.			
Phlogiſton	Phlogiſton	Phlogiſton	Prussian Acid.			
Veg. alkali	Barytes	Barytes	In the Humid Way.	Lime	Barytes	Barytes
Min. alkali	Veg. alkali	Veg. alkali	Veg. alkali	Barytes	Lime	Veg. alkali
Barytes	Min. alkali	Min. alkali	Min. alkali	Magneſia	Magneſia	Min. alkali
Lime	Lime	Lime	Vol. alkali	Veg. alkali	Veg. alkali	Lime
Magneſia	Magneſia	Magneſia	Lime	Min. alkali	Min. alkali	Magneſia
Metallic calces	Metallic calces	Metallic calces	Barytes	Metallic calces	Metallic calces	Metallic calces
Vol. alkali	Vol. alkali	Vol. alkali	Magneſia	Vol. alkali	Vol. alkali	Vol. alkali
Clay	Clay	Clay	Clay	Clay	Clay	Clay
		N. B. Aqua regia follows the ſame order both in the humid and dry way.	Metallic calces	N. B. The ſame order both in the humid and dry way is followed by the acids of ſpar; of arſenic; of benzoin; of ſugar or milk; of fat; and of phoſphorus: except that phlogiſton occupies the firſt place in the dry way with the arſenical acid.		N. B. The ſame order both in the humid and dry way is followed by the acids of milk and of ants.
			Water			

TABLE VII. Simple Elective Attractions.

ALKALIS AND EARTHS.

IN THE HUMID WAY.

VEG. ALKALI	MIN. ALKALI	CLAY.	LIME.	BARYTES.	MAGNESIA.
Vitriolic acid	This alkali agrees with the vegetable in the order of its attractions, both in the humid and the dry way.	Vitriolic acid	A. of ſugar	Vitriolic acid	Acid of ſugar
Nitrous acid		Nitrous a.	Vitriolic a.	A. of ſugar	Phoſphor. a.
Marine acid		Marine a.	A. of tartar	A. of amber	Vitriolic acid
Acid of fat		A. of ſugar	A. of amber	A. of ſpar	A. of ſpar
Acid of ſpar		Arſenical a.	Phoſphor. a.	Phoſphor. a.	A. of fat
Phoſphor. acid		Sparry a.	A. of ſ. of milk	A. of ſ. of milk	A. of arſenic
A. of ſugar		A. of fat	Nitrous acid	Nitrous acid	A. of ſ. of milk
A. of tartar		A. of tartar	Marine acid	Marine acid	A. of amber
A. of arſenic		A. of amber	A. of fat	A. of fat	Nitrous acid
A. of amber		A. of ſ. of milk	A. of ſpar	A. of lemon	Marine acid
A. of lemon		A. of lemon	A. of arſenic	A. of tartar	A. of tartar
A. of ants	VOL. ALKALI. This alkali agrees with the vegetable in the order of its attractions, both in the humid and dry way: but mere heat expels it from the acids of phoſphorus, borax, and arſenic.	Phoſphor. a.	A. of ants	A. of arſenic	A. of lemon
A. of milk		A. of ants	A. of milk	A. of ants	A. of ants
A. of benzoin		A. of milk	A. of lemons	A. of milk	A. of milk
Acetous acid		A. of benzoin	A. of benzoin	A. of benzoin	A. of benzoin
A. of ſ. of milk		Acetous acid	Acetous acid	Acetous acid	Acetous acid
Acid of borax		A. of borax	Acid of borax	Acid of borax	A. of borax
Vol. vitr. a.		Vol. vitr. a.	Vol. vitr. a.	Vol. vitr. a.	Vol. vitr. a.
Fuming nitr. a.		Fum. nitr. a.	Fum. nitr. a.	Fum. nitr. a.	Fum. nitr. a.
Fixed air		Fixed air	Fixed air	Fixed air	Fixed air
Pruſſian acid		Pruſſian acid	Pruſſian a.	Pruſſian a.	Pruſſian a.
Water			Water	Water	
Fat oils			Fat oils	Fat oils	
Sulphur			Sulphur	Sulphur	Sulphur
Met. calces					

IN THE DRY WAY.

VEG. ALKALI	SILEX.	CLAY.	LIME.	BARYTES.	MAGNESIA.
Phoſphor. acid	In the HUMID WAY.	Phoſphor. acid	Phoſphor. acid	Phoſphor. acid	Phoſphor. acid
A. of borax	A. of ſpar	A. of borax	A. of borax	A. of borax	A. of borax
A. of arſenic	Veg. alkali	A. of arſenic	A. of arſenic	A. of arſenic	A. of arſenic
Vitriolic acid	In the DRY WAY	Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid
Nitrous acid	Fixed alkali	Nitrous acid	A. of amber	A. of amber	A. of ſpar
Marine acid	Phoſphor. acid	Marine acid	Nitrous acid	Acid of ſpar	A. of fat
A. of fat	Calx of lead	A. of ſpar	Marine acid	Nitrous acid	A. of amber
A. of ſpar		A. of fat	A. of fat	Marine acid	Nitrous acid
A. of amber		A. of amber	A. of ſpar	A. of fat	Marine acid
A. of ants		A. of ants	A. of ants	A. of ants	A. of ants
A. of milk		A. of milk	A. of milk	A. of milk	A. of milk
A. of benzoin		A. of benzoin	A. of benzoin	A. of benzoin	A. of benzoin
Acetous acid		Acetous acid	Acetous acid	Acetous acid	Acetous acid
Barytes		Fixed alkali	Fixed alkali	Fixed alkali	Fixed alkali
Lime		Sulphur	Sulphur	Sulphur	Sulphur
Magneſia		Calx of lead	Calx of lead	Calx of lead	Calx of lead
Clay					
Silex					
Sulphur					

TABLE VIII. Simple Elective Attractions.

COMBUSTIBLE SUBSTANCES AND WATER.

IN THE HUMID WAY.

WATER.	SULPHUR.	SALINE LIVER OF SULPHUR.	ARDENT SPIRIT	ETHER.
g. alkali	Calx of lead	Calx of gold	Water	Ardent ſpirit
in. alkali	C. of tin	C. of ſilver	Ether	Eſſential oils
ol. alkali	C. of ſilver	C. of mercury	Eſſential oils	Expreſſed oils
rdent ſpirit	C. of mercury	C. of arſenic	Volatile alkali	Water
ild vol. alk.	C. of arſenic	C. of antimony	Fixed alkali	Sulphur
lauber's ſalt	C. of antimony	C. of biſmuth	Saline hepar	
ther	C. of iron	C. of copper	Sulphur	
	Veg. alkali	C. of tin		
	Vol. alkali	C. of lead		
	Barytes	C. of nickel		
	Lime	C. of cobalt		
	Magneſia	C. of manganeſe		
itriolic acid		C. of iron		
itriolated tartar	Fat oils			
lum	Eſſential oils	Ardent ſpirit		
artial vitriol	Ether	Water		
orroſ. ſublimate	Ardent ſpirit			

EXPRESSED OIL	ESSENTIAL OIL
Ether	Ether
Eſſential oils	Ardent ſpirit
Fixed alkalis	Fat oils
Vol. alkali	Fixed alkalis
Sulphur	Sulphur

IN THE DRY WAY.

Fixed alkali	Manganeſe
Iron	Iron
Copper	Copper
Tin	Tin
Lead	Lead
Silver	Silver
Cobalt	Gold
Nickel	Antimony
Biſmuth	Cobalt
Antimony	Nickel
Mercury	Biſmuth
Arſenic	Mercury
	Arſenic

Four of the columns in the original tables of Bergman are omitted in theſe, viz.

The perlate acid; for which ſee page 209.

Vital air, which is ſuppoſed to have an affinity to phlogiſton only.

The matter of heat; for which ſee pages 6. 21.

The ſemimetal ſiderite; for which ſee page 313.

TABLE IX. Simple Elective Attractions.

PHLOGISTON AND METALS.

IN THE HUMID WAY.

PHLOGISTON	CALX OF GOLD	C. OF SILVER	C. OF PLATINA	C. OF MERCURY.	C. OF LEAD.
Nitrous acid	Ether	Marine acid	Ether	Acid of fat	Vitriolic acid
Vitriolic acid	Marine acid	Acid of fat	Marine acid	Marine acid	Acid of fat
Dephl.marine a.	Aqua regia	Acid of ſugar	Aqua regia	Acid of ſugar	A. of ſ. of milk
Arſenical acid	Nitrous acid	Vitriolic acid	Nitrous acid	Acid of amber	A. of ſugar
Phoſphor. acid	Vitriolic acid	A. of ſ. of milk	Vitriolic acid	Arſenical acid	Arſenical acid
	Arſenical acid	Phoſphor. acid	Arſenical acid	Phoſphor. acid	Acid of tartar
C. platina	Sparry acid	Nitrous acid	Sparry acid	Vitriolic acid	Phoſphor. acid
C. gold	Acid of tartar	Arſenical acid	Acid of tartar	A. of ſ. of milk	Marine acid
C. ſilver	Phoſphor. acid	Sparry acid	Phoſphor. acid	Acid of tartar	Nitrous acid
C. mercury	Acid of fat	Acid of tartar	Acid of fat	Acid of lemon	Sparry acid
C. arſenic	Pruſſian acid	Acid of lemon	Acid of ſugar	Nitrous acid	Acid of lemons
C. antimony		Acid of ants	Acid of lemons	Sparry acid	Acid of ants
C. biſmuth		Acid of milk	Acid of ants	Acetous acid	Acid of milk
C. copper		Acetous acid	Acid of milk	Acid of borax	Acetous acid
C. tin		Acid of amber	Acetous acid	Pruſſian acid	Acid of borax
C. lead		Pruſſian acid	Acid of amber	Fixed air	Pruſſian acid
C. nickel		Fixed air			Fixed air
C. cobalt	Fixed alkali				Fixed alkali
C. manganeſe	Vol. alkali	Vol. alkali			
C. iron					
C. zinc					
Water					

N. B. In the antiphlogiſtic theory, the column intitled *Phlogiſton* being taken in a reverſed order, will expreſs the elective attractions of *Vital air*.

IN THE DRY WAY.

	GOLD.	SILVER.	PLATINA.	MERCURY.	LEAD.
C. of platina	Mercury	Lead	Arſenic	Gold	Gold
C. gold	Copper	Copper	Gold	Silver	Silver
Acid of arſenic	Silver	Mercury	Copper	Platina	Copper
C. ſilver	Lead	Biſmuth	Tin	Lead	Mercury
C. mercury	Biſmuth	Tin	Biſmuth	Tin	Biſmuth
C. arſenic	Tin	Gold	Zinc	Zinc	Tin
C. antimony	Antimony	Antimony	Antimony	Biſmuth	Antimony
C. biſmuth	Iron	Iron	Nickel	Copper	Platina
C. copper	Platina	Manganeſe	Cobalt	Antimony	Arſenic
C. tin	Zinc	Zinc	Manganeſe	Arſenic	Zinc
C. lead	Nickel	Arſenic	Iron	Iron	Nickel
C. nickel	Arſenic	Nickel	Lead		Iron
C. cobalt	Cobalt	Platina	Silver		
C. manganeſe	Manganeſe		Mercury		
C. iron	Sa. liv. of ſulph.	S. l. of ſulph.	S. l. of ſulph.	S. l. ſulph.	S. l. ſulphur
C. zinc		Sulphur		Sulphur	Sulphur

TABLE X. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.

Calx of Copper.	Calx of Iron.	Calx of Tin.	Calx of Biſmuth.	Calx of Nickel.	Calx of Arſenic.
Acid of ſugar	Acid of ſugar	Acid of fat	Acid of ſugar	Acid of ſugar	Marine acid
Acid of tartar	Acid of tartar	Acid of tartar	Acid of arſenic	Acid of ſorrel	Acid of ſugar
Marine acid	Vitriolic acid	Marine acid	Acid of tartar	Marine acid	Vitriolic acid
Vitriolic acid	A. of ſ. of milk	Vitriolic acid	Phoſphor. acid	Vitriolic acid	Nitrous acid
A. of ſ. of milk	Marine acid	Acid of ſugar	Vitriolic acid	Acid of tartar	Acid of fat
Nitrous acid	Nitrous acid	Arſenical acid	Acid of fat	Nitrous acid	Acid of tartar
Acid of fat	Acid of fat	Phoſphor. acid	Marine acid	Acid of fat	Phoſphor. acid
Arſenical acid	Phoſphor. acid	Nitrous acid	Nitrous acid	Phoſphor. acid	Acid of ſorrel
Phoſphor. acid	Arſenical acid	Acid of amber	Fluor acid	Fluor acid	Fluor acid
Acid of amber	Sparry acid	Sparry acid		A. of ſ. of milk	A. of ſ. of milk
Sparry acid	Acid of amber	A. of ſ. of milk		Acid of amber	Acid of amber
Acid of lemon	Acid of lemons	Acid of lemons		Acid of lemon	Acid of lemon
Acid of ants	Acid of ants	Acid of ants		Acid of ants	Acid of ants
Acid of milk	Acid of milk	Acid of milk		Acid of milk	Acid of milk
Acetous acid	Acetous acid	Acetous acid		Acetous acid	Arſenical acid
Acid of borax	Acid of borax	Acid of borax		Arſenical acid	Acetous acid
Pruſſian acid	Pruſſian acid	Pruſſian acid		Acid of borax	
Fixed air	Fixed air			Pruſſian acid	Pruſſian acid
Fixed alkali		Fixed alkali		Aerial acid	
Vol. alkali		Vol. alkali		Volatile alkali	Volatile alkali
Fat oils					Unctuous oils
					Water

IN THE DRY WAY.

Copper.	Iron.	Tin.	Biſmuth.	Nickel.	Arſenic.
Gold	Nickel	Zinc	Lead	Iron	Nickel
Silver	Cobalt	Mercury	Silver	Cobalt	Cobalt
Arſenic	Manganeſe	Copper	Gold	Arſenic	Copper
Iron	Arſenic	Antimony	Mercury	Copper	Iron
Manganeſe	Copper	Gold	Antimony	Gold	Silver
Zinc	Gold	Silver	Tin	Tin	Tin
Antimony	Silver	Lead	Copper	Antimony	Lead
Platina	Tin	Iron	Platina	Platina	Gold
Tin	Antimony	Manganeſe	Nickel	Biſmuth	Platina
Lead	Platina	Nickel	Iron	Lead	Zinc
Nickel	Biſmuth	Arſenic	Zinc	Silver	Antimony
Biſmuth	Lead	Platina		Zinc	
Cobalt	Mercury	Biſmuth			
Mercury		Cobalt			
Sal. liv. of ſulph.	S. l. of ſulphur	S. l. of ſulph.	S. l. of ſulph.	S. l. of ſulph.	S. l. of ſulph.
Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur

TABLE XI. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.

Calx of Cobalt.	Calx of Zinc.	Calx of Antimony.	Calx of Manganeſe.	Calx of Wolfram.
Acid of ſugar	Acid of ſugar	Acid of fat	Acid of ſugar	Lime
Acid of ſorrel	Vitriolic acid	Marine acid	Acid of ſorrel	Vegetable alkali
Marine acid	Marine acid	Acid of ſugar	Acid of lemon	Volatile alkali
Vitriolic acid	Acid of ſ. of milk	Vitriolic acid	Phoſphoric acid	
Acid of tartar	Nitrous acid	Nitrous acid	Acid of tartar	
Nitrous acid	Acid of fat	Acid of tartar	Fluor acid	
Acid of fat	Acid of ſorrel	Acid of ſorrel	Marine acid	In the Dry Way.
Phoſphoric acid	Acid of tartar	Acid of ſ. of milk	Vitriolic acid	Fixed alkali
Fluor acid	Phoſphoric acid	Phoſphoric acid	Nitrous acid	Lime
Acid of ſ. of milk	Acid of lemon	Acid of lemon	Acid of ſ. of milk	Calx of iron
Acid of amber	Acid of amber	Acid of amber	Acid of amber	Calx of manganeſe
Acid of lemon	Fluor acid	Fluor acid	Acid of fat	
Acid of ants	Arſenical acid	Arſenical acid	Arſenical acid	This column is additional. It is deduced from De Luyart's Analyſis.
Acid of milk	Acid of ants	Acid of ants	Acid of ants	
Acetous acid	Acid of milk	Acid of milk	Acid of milk	
Arſenical acid	Acetous acid	Acetous acid	Acetous acid	
Acid of borax	Acid of borax	Acid of borax		
Pruſſian acid	Pruſſian acid	Pruſſian acid	Pruſſian acid	
Aerial acid	Aerial acid	Aerial acid	Aerial acid	
Volatile alkali	Volatile alkali			

IN THE DRY WAY.

Cobalt.	Zinc.	Antimony.	Manganeſe.	Wolfram.
Iron	Copper	Iron	Copper	Iron
Nickel	Antimony	Copper	Iron	Silver
Arſenic	Tin	Tin	Gold	Tin
Copper	Mercury	Lead	Silver	Lead
Gold	Silver	Nickel	Tin	Antimony
Platina	Gold	Silver		Biſmuth
Tin	Cobalt	Biſmuth		Manganeſe
Antimony	Arſenic	Zinc		Gold
Zinc	Platina	Gold		Platina
	Biſmuth	Platina		
	Lead	Mercury		
	Nickel	Arſenic		
	Iron	Cobalt		
Saline liv. of ſulph.		Sal. liv. of ſulphur	Sal. liv. of ſulphur	
Sulphur		Sulphur		

TABLE XII. Numerical Expreſſion of Attractions by M. Morveau.

	Vitriolic Acid.	Nitrous Acid.	Marine Acid.	Acetous Acid.	Aerial Acid or Fix. Air.
Ponderous earth	65	62	36	29	14
Vegetable alkali	62	58	32	26	9
Mineral alkali	58	50	28	25	8
Lime	54	44	20	19	12
Volatile alkali	46	38	14	20	4
Magneſia	50	40	16	17	6
Argil. earth	40	36	10	15	2

TABLE XIII. Of the Proportion of Ingredients in Earths and Stones.

Calcareous Genus.

100 Parts.	Calcar.	Argill.	Silex.	Mag.	Wat.	Iron.
Calcareous ſpar	55	- -	- -	—	11	—[a]
Gypſum	32	- -	- -	—	38	—[b]
Fluor	57	- -	- -	—	—	—[c]
Tungſten	50	- -	- -	—	—	—[d]
Compound ſpar	60	- -	- -	35	—	5[e]
Cruetzenwald ſtone	75	- -	- -	12	—	3[f]
Calcareous marle	50 to 75	20 to 30	20 to 30	—	—	—[g]
Margodes	50	32	15	—	—	2
Stellated ſpar	66	- -	30	—	—	3
Calcareous grit or ſand ſtone	50	- -	- -	—	—	—[h]
Swine ſtone	95	- -	- -	—	—	—[i]
Pyritaceous limeſtone	75	14	- -	—	—	4[k]
Martial tungſten	- -	- -	- -	—	—	50[l]

a And 34 fixed air. —— *b* And 30 vitriolic acid. —— *c* 43 acid and water. —— *d* 50 acid and iron. —— *e* Both earths mild. —— *f* Ditto. —— *g* And water. —— *h* Or more; remainder, ſilex, argill. and iron. —— *i* And petrol.; remainder, argill. and iron. —— *k* And 7 quartz and ſulphur, that is, 25 pyrites. —— *l* By the dry way only 30, and 50 tungſten.

Barytic or Ponderous Genus.

100 Parts.	
Mild barytes	78 Earth, 20 fixed air, 2 baroſelenite.
Baroſelenite	84 Earth, 13 vitriolic acid, and 3 water.
Hepatic ſtone	33 Baroſelenite, 33 ſilex, 22 alum, 7 gypſum, 5 petroleum.

Muriatic or Magneſian Genus.

100 Parts.	Silex.	Calc.	Magneſia.	Argill	Water.	Iron.
Mild magneſia - - -	—	—	48	—	22	—
Keſſekil - - -	50	—	50	—	—	—
Steatites - - -	80	—	17	2	—	1
Argillaceous ſteatites -	72	—	17	11	—	—
Chalk of Briançon -	70	—	17	11	—	—†
Soap rock - -	70	—	17	13	—	—
Aſbeſtos - - -	63	11	20	4	—	2‡
Martial aſbeſtos - -	62	12	13,7	1,7	—	10,6
Suber montanum - -	59	11	24	2,4	—	3,6‖
Amianthus - -	64	6,9	18,6	3,3	—	1,2§
Serpentine - -	45	—	23	18	12	3
Talc, Muſcovy - -	50	—	45	5	—	—

Talc, Venetian - - a larger portion of argill. and ſmaller of magneſia.

Note, The magneſia and calcareous earths are in a mild ſtate, in all the above ſtones.

* At a medium, and 30 fixed air.——† And 2 of talc.——‡ At a medium.——‖ At a medium.——§ And 6 barytes.

Argillaceous Genus.

100 Parts.	Silex.	Argill	Calcareous	Magneſia.	Iron.	Water.
Pure clay, dry -	63	37*	—	—	—	—
Argillac. marl, dry -	46	27	25 †	—	—	—
Fullers earth -	53	18	5	3	4	17 ‡
Pouzzolana - -	57	20	6	—	20	—
Tripoli - -	90	7	—	—	3	—
Pure mica - -	38	28	—	20	14 ‖	—
Martial mica -	34,5	25,5	—	18	22	—
Roof ſlate or ſhiſtus	46	26	4 mild	8 mild	14	—
Flagſt. or argill. ſhiſt.	36	56	—	—	4	—
Horn-ſtone - -	37	22	2	16	23	—
Killas - - -	60	25	—	9	6	—
Toadſtone - -	63	14	7	—	16	—
Zeolyte - -	60	20	8	—	—	12 §
Pitch-ſtone -	65	16	—	—	5	14 ¶

Gronſten - -	Horn-ſtone and mica, or horn-ſtone and ſhoerl.
Stellſten - -	Mica, quartz and argill.
Binda - -	Horn-ſtone, mica, ſhoerl, quartz, and pyrites.
Growan - -	Argill. mica, and quartz.

* At a medium, when perfectly dry, 63 ſiliceous——† Mild at a medium. ‡ And marine acid at a medium.——‖ White calx of iron.——§ At a medium.——¶ And air.

Siliceous

Siliceous Genus.

100 Parts.	Silex.	Argill	Calcar.	Magn.	Iron.
Cryſtal - - -	93	6	1	—	—
Flint - - -	80	18	2	—	—
Petroſilex - -	72	22	6	—	—
Jaſper - - -	75	20	—	—	5
Chalcedonian - -	84	16	—	—	—
Ruby - - -	39	40	mild 9	—	10
Topaz - - -	39	46	ditto 8	—	6
Hyacinth - -	25	40	dit. 20	—	13
Emerald - - -	24	60	8	—	6
Sapphire - - -	35	58	5	—	2
Chryſopraſium - -	95	—	1,7	1,2	0,4[a]
Lapis lazuli - -	—	—	—	—	—[b]
Felt ſpar - -	67	14	—	8	—[c]
Veſuvian garnet -	55	39	6	—	—
Garnet - - -	48	30	12	—	10
Martial garnet - -	43,6	27,6	10	—	19
Shoerl tranſparent -	48	40	5	1	5
Shoerl black - -	58	27	5	1	5
Bar ſhoerl - - -	61,6	6,6	21,6	5	1,6[d]
Tourmaline - -	37	45	13	—	5[e]
Baſaltes - - -	52	15	8	2	25
Rowley ragg - -	47,5	32,5	—	—	20
Comp. and cellular lava	47	30	5	—	18
Vitreous ditto - -	49	35	4	—	12
Another from Lapari -	69	22	—	—	9
Black agate of Iceland nearly as the above	—	—	—	—	—
Pumice ſtone - -	84 or 90	—	—	6 to 15	—[f]
Martial muriatic ſpar -	50	—	—	30 mild	20[g]
Turkey ſtone - -	70	5	mild 25	—	—[h]
Ragg ſtone - -	70	5	dit. 20	—	5[i]
Siliceous grit, with calcareous cement	62,5	--	do.37,5	—	—
Siliceous ditto, with argillaceous cement -	77	20	—	—	3[k]
Ditto, with ferruginous cement - -	80	5	—	—	15[l]

[a] 0,6 copper, and ſparry acid.——[b] 80 martial fluor, 20 gypſum, as I believe.——[c] 11 ponderous.——[d] 5 water.——[e] At a medium. [f] Remainder calcareous.——[g] As I believe.——[h] As I believe. [i] As I believe.——[k] As I believe.——[l] As I believe.

Siliceous Genus continued.

Granite - -	Quartz, felt ſpar and mica. Quartz, felt ſpar and ſhoerl.
Stellſten - - Granitello - -	Quartz and mica.
Rapakivi - - Granitone - -	Felt ſpar and mica.
Murkſten - - Norka - - -	Quartz, garnet, and mica.
Porphyry - -	Jaſper, chert, lava, ſhoerl containing quartz, felt ſpar, ſhoerl, mica, or ſerpentine in a cryſtalline form.
Pudding ſtone - -	Jaſper, chert, ſiliceous grit, or lava, containing pebbles of an oval form.
Siliceous breccias -	The ſame ground and contents, but in angular forms.
Gneiſs - - -	Quartz, mica, ſteatites. Quartz, mica, ſerpentine. Quartz, mica, ſhoerl, ſteatites, or ſoap rock. Quartz, felt ſpar, mica, ſerpentine.
Amygdaloides - -	Jaſper, or chert, containing ſpar or ſerpentine.
Metallic rock of Born	Quartz, clay, and ſteatites, and felt ſpar ſometimes.
Variolite - -	Serpentine, containing various ſtones.

Proportion of Ingredients in Natural Salts.

Salts.	Acids	Alka.	Earth	Water.	
Tartar vitriolate -	31	63	—	6	
Glauber's ſalt -	14	22	—	64	
Vitriolic ammoniac -	42	40	—	18	
Epſom - -	24	—	19	57	
Alum - -	24	—	18	58	
Vitriol of iron -	20	—	—	55	25 iron.
Ditto of copper -	30	—	—	43	27 copper.
Ditto of zinc -	22	—	—	58	20 zinc.
Nitre - -	30	63	—	7	
Cubic nitre - -	29	50	—	21	
Nitrous ammoniac	46	40	—	14	
Nitrous ſelenite -	33	—	32	35	
Ditto Epſom -	36	—	27	37	
Salt of Silvius -	30	63	—	7	
Common ſalt -	33	50	—	17	
Sal ammoniac -	52	40	—	8	
Marine ſelenite -	42	—	38	20	
Borax purified -	34	17	—	47	

I N D E X.

A.

ACHROMATIC teleſcope, 269
Acids, 124
id, acetous, 460, 482
id of amber, 198
id of ants, 523
id of apples, 431
id, arſenical, 211, 359
id of benzoin, 435
id of borax, 193
id of camphor, 451
id of cork, 451
id of fat, 516
id of galls, 432
id of lemons, 428
d, marine, 173
d, dephlogiſticated marine, 176
d of milk, 492
d of molybdena, 215
d, nitrous, 151, 156
d of phoſphorus, 204
d, Pruſſian, 303
d of ſilk worms, 504
d of ſpar, 196
d of the ſtone of the bladder, 507
d of ſugar, 444, 449—empyreu-
iatic, 447
d of ſugar of milk, 496
d of tartar, 441—empyreumatic,
46
d of tin, 337
l of tungſten, 216
l, vitriolic, 140
l of wood, empyreumatic, 447
mantine ſpar, 108
egation, 74
alkaline, 123
fixed, 183
hepatic, 139
inflammable, 95
marine, 173
nitrous, 94, 159
phoſphoric, 205
Air, vital, 94
Air, vitriolic, 144
Alembic, 36
Alembroth, 262
Algaroth, 380
Alkali, 114
Alloys, 131
Alum, 142
Amalgam, 265
Amber, 198
Ambergris, 508
Ammoniac, ſal, 120, 175
Analyſis, 1
Animals, 411
Antimony, 263, 378
Aqua regia, 180
Arſenic, 212, 356
Aſſaying, 130
Aſphaltum, 402
Atmoſphere, 93
Attraction, 2, 3, 71, 78
Aurum muſivum, 342

B.

Balance, 59
Balſams, 139
Barbadoes tar, 402
Barytes, 105
Bath, 38
Beer, 464
Benzoin, 434
Bell metal, 285
Bezoar mineral, 380
Bile, 520
Biſmuth, 349
Bleaching, 177, 499
Blood, 510
Blow-pipe, 43
Bones, 519
Borax, 191
Braſs, 288
Bread, 461
Bronze, 285
Butter, 497

INDEX.

C.

Calamine, 376
Calcination, 33
Calomel, 261, 263
Camphor, 423
Candles, 500
Caſſius, powder of, 225
Celſius, 30
Cementation, 34
Ceruſe, 270
Charcoal, 185, 454
Cheeſe, 494
Chemiſtry defined, 1
Cinnamel, 264
Coating, 38
Cobalt, 366
Colcothar, 300
Colouring matters, 425
Combination, 74
Combuſtion, 32, 94
Concentration, 34
Crawford, Dr. 11
Copper, 278
Cream, 497
Crucibles, 35
Cryſtallization, 81, 128
Cucurbits, 35
Cupellation, 231

D.

Detonation, 154
Diamond, 405
Digeſtion, 34
Diſtillation, 34, 452
Dutch gold, 288
Dying, 426

E.

Earths, 99
Eggs, 497
Eliquation, 273
Elements, 75
Elutriation, 345
Eolipile, 97
Ethers, 472
Ethiops mercurial, 264
Eudiometer, 162
Evaporation, 34
Excrement, 507
Extenſion, 71

F.

Fahrenheit, 30
Fat, 516
Fermentation, 457
Fleſh, 514
Flour, 419
Freezing, 18
Fuel, 38
Fulminating powder, 156
Furnaces, 37
Fuſion, 34

G.

Gaſtric fluid, 522
Glaſs, 120
Glue, 513
Gluten, vegetable, 420
Gold, 221
Gravity, 72
Grotto del Cano, 184
Gum, 417
Gunpowder, 154
Gypſum, 104, 143

H.

Hair, 505
Heat, 2, 5, 87
Homberg's phoſphorus, 175
Honey, 498

I.

Jargon of Ceylon, 110
Jelly, 513
Jet, 402
Inertia, 71
Inflammation, ſpontaneous, 165, 310.
341, 392
Ink
Integrant, 74
Iron, 293

K.

Kermes mineral, 382
Kier, his acid, 169, 241
Koumiſs, 465

L.

Lac, 502
Lead, 268
Libavius; fuming liquor of, 338
Light, 87
Litharge, 269
Liver of ſulphur, 137
Luna cornea, 238
Lunar, cauſtic, 238
Lutes, 39

INDEX.

M.

Magneſia, 106
Magiſtery of biſmuth, 350
Malt, 464
Mangancſe, 386
Matraſs, 35
Mercury, 256
Metals, 85, 127
Metheglin, 465
Milk, 491
Mines, 129
Minium, 268
Mixture, 74
Molybdena, 215

N.

Nickel, 353
Nitre, 151
Nooth, Dr. 54

O.

Oils, fat, 420
—— volatile or eſſential, 423
Orpiment, 358

P.

Parting, 232
Peat, 402
Petroleum, 402
Pewter, 343
Phoſphorus, 200
Phlogiſton, 89, 93
Pit-coal, 402
Pitch-blende, 398
Platina, 251
Plumbago, 326—332
Polarity, 81
Precipitate per ſe, 256, 265—red, 259
Precipitation, 77
Principles, 75, 83
Proceſſes, 33
Pruſſian blue, 302
Putty, 346
Pyrites, 135

Q.

Quartation, 232

R.

Realgar, 358
Reaumur, 30
Receivers, 36
Rectification, 34
Regulus, 128
Reſins, 423
Reſpiration, 94
Retorts, 35
Roaſting, 33

S.

Salt, common, 170
Salts, 85
Saturation, 76
Serum, 512
Siderite, 313
Silk, 504
Silver, 236
Smalt, 370
Smell, 424
Soap, 119
Solder, 129, 273
Solvent, 76
Sorrel, ſalt of, 442
Speculum metal, 285
Spelter, 377
Spermaceti, 517
Spirit, ardent, 459, 461, 466
Starch, 420
Steam, 17
Steel, 320
Stills, 36
Stone of the bladder, 506
Sublimation, 34
Sublimate, 35—corroſive, 261
Sugar, 418
—— of lead, 271
—— of milk, 494
Sulphur, 135
Suſpenſion, 75
Syntheſis, 1

T.

Tallow, mineral, 402
Tartar, 437, 461
Temperature, 6
Terms, 4
Thermometer, 10, 16, 23, 102
Tin, 334
Tin plate, 313
Touch-needles, 233
Tree of Diana, 243
Tungſten, 215
Turbith mineral, 258

U, V.

Uranite, or uranium, 398
Urine, 506

Vegetables,

Vegetables, 410
Verdigris, 281
Vermilion, 264
Vinegar, 460

W.

Water, 76, 95
Wax, 498
Weights, 65
Welding, 252, 324
Wine, 463
Wolfram, 216, 394
Wool, 505

Y.

Yeaſt, 459, 461

Z.

Zaffre, 370
Zinc, 372